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THE RELATIONS OF RAILWAY MANAGERS AND EMPLOYÉS.

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I.

THE problem how to secure the most effective and harmonious relationship with their employés is one of rapidly growing importance in the minds of those managers whose duties bring them into close contact with the rank and file of railway service, and is also beginning to force itself upon the attention of investors in this country, as it has already largely done in Europe. Though quite generally the real underlying cause of strikes and labor agitations, among railway people especially, is unequal enforcement of discipline, irregularity in or unequal distribution of work, debts incurred through the misfortunes—rather than, as a rule, through the fault—of the operatives, inducing restlessness, etc., their discontent usually forces itself upon the attention of the railway director in the first instance as a *wages* question. As the successful and economical operation of a railway requires a certain number of *reliable* servants thoroughly trained for and skilled in their respective positions, considering the rapid extension of our railways, many years must elapse before the surplusage so cheapens this class of skilled labor as, on the one hand, to induce managers to relieve overburdened servants in busy seasons by dividing their duties among a larger number than will barely suffice for current needs, or, on the other, affords them security from strikes and unjust demands through the presence of unemployed skilled artisans eager to supplant the discontented. Meanwhile the necessity of meeting competition and reduced earnings by improved machinery and increased technical efficiency will constantly enhance the importance and value of a permanent and zealous corps of employés with whom fair wages,

while important, are overshadowed by other considerations personal to their service. In its simplest aspects the subject of the wisest form of adjustment between labor and capital is enough; but, when considered in relation to our American railways, so many and complicated questions of management and economies arise, and the possible consequences of innovations are so great and serious, that few officials possessing sufficient influence with their directors and stockholders to make their advocacy effective have time or courage to take the initiative in an intelligent reform, which, under the most favorable circumstances, could only be established by overcoming the timidity of capital and the obstinate opposition of the ignorant and prejudiced. At first blush the proposition that intelligent beings would not welcome with hearty support and co-operation any measure whose patent object was the improvement of their welfare seems untenable, but the student of history will recall few instances where the violent opposition of the masses has not followed all general efforts to ameliorate their condition, since and before the day when the founder of the Christian religion suffered crucifixion for his temerity in a kindred cause. It is generally recognized at home and abroad that only through the betterment of their present physical condition and surroundings can a body of permanent, satisfied railway servants be secured; yet the path to success in such an enterprise is strewed with many difficulties, the primary one in this country arising from the absentee ownership of our great railroads, and the difficulty which a body of stockholders, or their representative directors, have in recognizing the needs and feelings of the rank and file operating their properties—living, as they do, far from their lines, or, if near, immersed in pursuits that do not bring them together. The ownership half of the railroad world—in the United States, at least—certainly knows little, and recks less, of how the employé half lives. True, no difficulty would probably be experienced in getting investors in railroad securities to admit, in glittering generalities, the desirability—even necessity—of bettering the condition of those upon whose energy, honesty, and fidelity they rely for dividends; but when confronted with any systematic measure for the accomplishment of this result, which apparently involves a considerable expenditure, they "back water" with alacrity. Philanthropy and benevolence find no resting-place in the bosoms of the average railroad shareholders; at least few think of beginning their charities among the homes of their people; therefore, to enlist their pecuniary support of any costly plan for helping railroad operatives, it must be shown *to pay the shareholder*. Treating the subject from a purely business stand-point, let us see *if it pays* our great corporations to rest their connection with their employés upon the mere payment of current wages.

At the close of the year 1884, 125,000 miles of railroad * were in

* These figures are quoted as the nearest estimates obtainable from the best authorities.

operation in the United States and 9,949 in Canada; the estimated gross earnings of which were, in round numbers: United States, $770,684,908; Canada, $33,421,767; and the net profits: United States, $268,064,496; Canada, $7,826,872. The year's freight traffic over those lines was: United States, 390,074,749 tons; Canada, 13,716,462; while the passengers carried a mile were estimated at: United States, 8,778,581,061. In Canada it is not given; but the total number of passengers carried was 9,984,354, against 334,570,766 in the United States. The business transacted over the lines was handled by an estimated force of 1,600,000 employés,* whose combined earnings, while unobtainable with accuracy, must have been enormous. Considering the magnitude of the interests involved—not only the value of the property operated, but the vast number of human beings who freely intrust their lives to the railroads—and the growing demand for increased speed in transportation, it needs little illustration to show that their responsibilities as common carriers are such as make it of paramount importance to their managements to secure and retain the services of the most experienced and reliable citizens obtainable; thereby obviating, as far as possible, the often fearful consequences of inexperience and negligence, and promoting public confidence by the knowledge that the lives and property of their patrons will not be subjected to unnecessary hazard. There are few employments in the country more onerous and exacting, and not any where negligence, inexperience, or absent-mindedness has more fatal consequences than those embraced in the operating departments of railways; hence the necessity of protecting themselves against the depressing influences to which most men, struggling against present or impending pecuniary difficulties, are susceptible, must be readily apparent.

In periods of activity such classes of labor are frequently overtasked, while in times of depressed trade their earnings are generally decreased by actual reduction of wages, or variable employment, to a bare subsistence. Then, when disability or old age overtakes them, few possess reserve earnings from which to draw for the necessaries of life.

In the report of the English Select Committee on Civil-Service Superannuation, it was stated that the dread of poverty had a very injurious effect on the minds and health of business-men, artisans, etc. The celebrated Dr. Farr, of England, when consulted upon the advantages of remuneration, partly by salaries and partly by provision for old age, thus sums up the evidence and arguments in favor of such an arrangement:

"In the first place, superannuation is a guarantee of fidelity; in the second place, it encourages efficient officers; in the third place, it retains good men in the service; in the fourth place, it induces men

* Estimate of United States Railroad Commissioner as to employés in the United States.

to retire when they become old or inefficient from any cause; and, in the fifth place, it prevents old servants from falling into disgraceful dependence, or distressing destitution, which would be a public scandal, and would deter desirable persons from entering the service."

It is not always true, in the history of railroads or other corporations, that the one paying the highest wages is best served. The company that is most forward in caring for the general welfare of its employés, particularly in the matter of providing support for those disabled, aged, and of long service; that holds all its officials to a rigid responsibility for arbitrary or tyrannical exercise of power; that convinces its lowest servants that they will be protected against injustice, even at the hands of their highest official superiors—will soon obtain such prominence among the masses as will bring to its service the best material the market affords, though it give no more than—nor often quite so much as—others, who regard their employés only as so much material to be utilized or expended in the interests they serve.

The writer has for a considerable time studied the relationship existing between the managers and employés of many of our large corporations, and his observations seem to justify the conclusion that, whereas, in no other business employing large bodies of labor is there a wider field for cultivating cordiality and reciprocity of interests between owners and employés than in railroading, also in no other business (except, perhaps, mining) have such opportunities been more neglected. The admirable results he has observed following even a partial recognition of the equities between the executives and the rank and file of one or two railroads affords a glimpse of the great possibilities—easily made certainties by proper cultivation—of community of interests and aspirations between the two, that in unsettled times must prove invaluable.

It is unnecessary here to analyze the causes which produce the discontent and lack of unity between managers and employés, painful to observe, but too generally prevalent in this country, where the fascinations and the *esprit de corps* of railroading are so great as to give powerful support to any systematic and liberal efforts to reach a better understanding. One prominent origin of the lack of attachment to corporate interests here alluded to may be cited by way of parenthesis, namely, the system prevalent on most railways under which subordinate officials may discharge those under them without explanation or question. Where rigid accountability has been substituted for such irresponsibility the happiest results have uniformly followed, for thereby the lowest as well as the highest individual in the service became assured that, while he might be suspended for a short time by the exercise of arbitrary authority, a full hearing and exact justice would ultimately be had from an unprejudiced tribunal; while such supervision over those vested with limited authority naturally made

them careful and discreet in exercising it. By uniform and consistent dealing with misdemeanors, not only is discipline preserved, but the culprits and all others concerned are made to understand that justice *only* will be administered, while harsh criticism and complaints of injustice receive no sympathy; the standard of service is elevated and its efficiency increased; and all fear of personally incurring the displeasure of superior officials, and the consequent currying of favor—generally to the company's disadvantage—are obviated.

Railroad companies not only need men sound in body, but in this country they frequently need the moral and political support of their employés. This, a mere wage *quid pro quo* will never develop. Why not, in addition, identify the interests of their employés with their own, either by that most potent of all bonds, pecuniary advantage, or otherwise engender personal devotion to those officials who are responsible for the conduct of the service?

As a rule the operatives of railroads reside in those counties and districts in which they work, and are more or less influential political factors. With us majorities rule, and as employés necessarily outnumber their employers, who are constantly compelled to seek concessions from political bodies, therefore, for their own welfare and safety, the latter should pursue such a policy as will enable them to count upon the support and friendship of their masters.

Mr. Charles Francis Adams, Jr., some years ago published in "The Nation" a communication from a correspondent who concluded some suggestions on promoting identity of interests between railroad managers and operatives with the following language: "The railroad man who makes suggestions of this character from the Western end of the line renders himself liable to have his ideas ranked as 'Utopian,' 'visionary,' etc. I have, however, been through the mill, and believe that a little attention to these matters would give our owners a more zealous and earnest service; would foster and preserve a higher *esprit de corps;* would develop a strong attachment to the line and its owners; would remove the possibility of strikes and riots; and would lead to the securing of a better grade of men, which means increased efficiency and increased net earnings; and all this can be secured at small cost and with little trouble to the local management."

That such views are not "Utopian" is proved by the fact that many of the principal English and Continental railway companies have on various occasions, and with considerable expenditure of time and money, inaugurated for their employés (and devoted large sums to sustaining) benevolent societies for promoting one or more of the objects the writer quoted outlined. Such action by financiers and railroad directors, whose keen business perceptions, stimulated by close competition, are not apt to be misdirected or clouded by philanthropical or sentimental ideas, shows how important they regard the cultivation of bonds of sympathy and fellowship with their armies of operatives—

susceptible as they are of an organization and discipline as perfect and efficient as distinguished the greatest armies of history.

If further proof of the utility of such action is desired, it can be had by observing the result attained by one of our Eastern trunk lines —the management of which has made itself prominent in organizing for its employés protection against financial distress resulting from sickness, accidents, old age, and other vicissitudes of life and death —which will be noticed further on—as also in the fact that such measures have actually and uniformly been found to compensate for material differences in wages; to put the service offering them at a premium, and ultimately to secure it the best and steadiest men at relatively insignificant outlay.

But it has often been asserted that corporations, no more than individuals, should enter into the philanthropy business, and that railroad companies are not more than other employers interested in the personal welfare of their people. Such assertions convict their authors of ignorance of social science and lack of forethought unpardonable in this advanced age in those intrusted with the overshadowing interests of our great American railways. In defense of such assertions it is alleged that individuals and classes of men are in the market representing labor, and other individuals or combinations of men representing capital are likewise in the market; that the one is perfectly justifiable in purchasing the other at its market value, and, when capital ceases to be able to pay the market value of labor, the other will naturally seek other purchasers, and that there the claims of one upon the other cease; that as labor is never held bound to maintain its connection with capital to the laborer's disadvantage, so, when labor ceases to make profit for capital, the latter must be allowed to exercise the same right to sever their associations.

While as a broad proposition this must be admitted to be true, railroads are, more than most other employers, interested in the prosperity of their employés, and, like all other corporations whose work is dangerous, are partly answerable for the misfortunes of their employés, and peculiarly interested in providing means for lessening liabilities to accident, and in relieving the suffering and hardships caused by injuries received in their service. In partial recognition of this principle, many individuals and corporations employing small bodies of labor continue the pay of their men when sick, but where large masses are to be dealt with such a course would entail an expenditure beyond all reason. As an illustration of this, on one of our Eastern trunk lines, the employés of which number something over twenty thousand (and several of its rivals have more than double this force), the sick and disabled from all causes have, within the writer's knowledge, numbered continuously more than six hundred per annum for at least four consecutive years. Increased remuneration for labor will not alone solve the problem under discussion, for railroad men are pro-

verbially improvident as a class, and under certain conditions increased payment means only greater extravagance. Therefore, a wise policy, if not higher considerations than those of self-interest, should prompt the managements of large corporations to provide, even at considerable expense or financial risk, not only for the protection of their employés from, or indemnity for the effects of, injuries, but also for their physical, mental, and moral improvement, so as to render them contented, zealous, and forbearing.

An admirable illustration of this fact is found in an inspection of the cotton-spinning factories of Windisch, near Zürich, the most extensive of this character on the Continent. Educated in England in all the technicalities and ramifications of his business, its present head, Mr. Hans Wonderly, has evidently imbibed and has put into practice many of the most advanced ideas respecting community of interests between employer and employé there prevalent. On the way to the mills one passes the hospital built by the firm, a pretty building healthily situated on a hill-side, near a sharp bend in the river Reuss, surrounded by flower-gardens and containing accommodations for thirty beds. At present it serves as a dispensary in which the district doctor dispenses medicines and advice at the expense of the firm. This firm provides neat cottages for over one hundred families of its workmen, conveniently located at short distances from their factories. Though it employs over a thousand operatives, and though it rents these cottages for only four pounds per annum, more than one half of its employés own their own houses, the surroundings of which are marvelous in beauty and neatness. The work-people remain in the firm's employ from generation to generation, and great kindness is shown their disabled and superannuated. Though at times embarrassment is experienced in providing employment for all who look with natural dependence upon it, this firm uniformly maintains its fatherly protection over all permanent employés. All its overlookers are trained on the spot, and the principle of giving its high positions to its own deserving people, which is strictly enforced, encourages aspiring young men to look for promotion at home rather than elsewhere. Thus a feeling of clannishness has been established which has kept its work-people united and satisfied, when at neighboring places all sorts of disputes and agitations have been in progress, and a strike has never occurred at any of its factories. This exemption from all labor troubles is attributed by the firm not alone to good management and satisfactory wages, but mainly to the great consideration and forbearance shown by the work-people themselves in times of financial depression. Time-breaking through drunkenness is unheard of in these factories. Well-organized schools for the young people are operated under the auspices of the firm, and there are also excellent night-schools wherein subjects interesting or advantageous to the operatives are taught free by instruction and lectures. The operatives

are supplied with food, clothing, and other necessaries, and with luxuries, through excellently organized co-operative stores, and a savings-bank and building association are also in operation under guarantee of the firm. The work-people are reported to be remarkably cleanly and well dressed, and to show in a high degree the effects of comfort and civilization, which, considering that, as compared with the English and American standards, their incomes are very small, is gratifying evidence of the beneficial effects of such a system (*vide* vol. i, "Second Report of the Royal Commissioners on Technical Education").

Another exemplification of the practical wisdom of what would by some be classed as Utopian ideas can to-day be found nearer home in the town of Pullman, near Chicago, where proper provision for the comfort and welfare of the *attachés* of the great works there located has secured for this manufacturing company the most skillful workmen in their respective departments probably to be found in the country; that without any marked increase of current wages has made a most satisfactory return for invested capital, and built up a town surrounded with influences that refine and elevate the minds and character, and permanently benefit alike the company and its workmen. Abundant evidence is furnished by manufacturing and other corporations abroad that paternal care and solicitude for their operatives are not thrown away, but tend in no small degree to establish good feeling and community of interest, and that, instead of conflicting with the cold calculations of business economy, such care is in reality the prompting of self-interest best understood. While railroads nor other corporations employing large masses of labor can withhold their employés altogether from improvidence and recklessness, from the consequences of which the employer must generally suffer, they can, by means kindred to those above suggested, compel their people to provide for their future welfare, and in other ways elevate their standard of efficiency; and neither the lukewarmness nor opposition of the servant releases the employer from an obvious duty to himself, his ward, and the public. Railroad corps especially are, like armies, amenable to rigid discipline judiciously applied, and where the necessity for self-protection is so obvious the justice of the employer inaugurating and *enforcing* measures promotive of their mutual interests will always be early recognized, and opposition will be sporadic and short-lived. Arguments and statements illustrative of the great necessity for the employer securing a closer affiliation, if not copartnership, between his interests and those of his employés through other and additional means than are now operating among our American railways, manufactories, etc., might be multiplied *ad nauseam;* but, on the assumption that the foregoing, if not within itself convincing, will at least suggest what will be conclusive upon this point, let us consider the manner in which substantial gain may be effected at least cost and with less risk to capital, premising the discussion with a

few remarks as to some of the troubles that are constantly arising under current methods :

By the laws of many of our States, railroads are held legally liable for physical damage to their employés, though resulting from causes beyond the reasonable control of executive management ; and the disbursements of those railroads whose lines traverse States in which public sentiment or the laws are at all hostile, on account of donations, judgments, costs, etc., for injuries to employés, form heavy and ever-increasing items in their operating expenses. In England a workman (in railroad or other hazardous service), when injured, or his legal personal representative in case the injury results in death, has the same right of compensation and remedies against the employer as if he had not been a workman, nor engaged in the service of the employer, though there the law is carefully discriminating, and is effective only when the injury is caused :

1. By reason of any defect in the condition of the ways, works, machinery, or plant connected with or used in the business of the employer ; or

2. By reason of the negligence of any person in the service of the employer who has any superintendence intrusted to him while in the exercise of such superintendence ; or

3. By reason of the negligence of any person in the service of the employer to whose orders or directions the workman at the time of the injury was bound to conform, and did conform, where such injury resulted from his having so conformed ; or

4. By reason of the act or omission of any person in the service of the employer done or made in obedience to the rules or by-laws of the employer, or in obedience to particular instructions given by any person delegated with the authority of the employer in that behalf ; or

5. By reason of the negligence of any person in the service of the employer who has the charge or control of any signal, points, locomotive-engine, or train upon a railway.

The workman has not the right of compensation nor any remedy against the employer :

1. Unless the defect causing the accident arose from, or had not been discovered or remedied owing to, the negligence of the employer, or of some person in the service of the employer, and intrusted by him with the duty of seeing that the ways, works, machinery, or plant were in proper condition.

2. Unless the injury resulted from some impropriety or defect in the rules, by-laws, or instructions of the employer.

3. In no case where the workman knew of the defect or negligence which caused his injury, and failed within a reasonable time to give or cause to be given information thereof to the employer or some person superior to himself, in the service of the employer, unless he was

aware that the employer or such superior already knew of the said defect or negligence.

The amount of compensation recoverable under this act may not exceed such sum as may be found to be equivalent to the estimated earnings, during the three years preceding the injury, of a person in the same grade employed during those years in the like employment and in the district in which the workman is employed at the time of the injury; but under our various State laws, when interpreted by juries, the measure of damages is usually severely onerous, if the employer be a railroad corporation, and, even when such cases are appealed to higher judicial tribunals, the tax costs are very heavy. In Germany, railroads—whether owned or controlled by the Government, or owned and managed by corporations—are not only legally compelled to assess their employés for the benefit of authorized relief funds, but are required to contribute thereto from their corporate funds—generally in amounts equaling the premiums collected from their members; and conformity to this regulation is invariably required in all the working departments of the roads.

In Great Britain, it has become quite general for employers to seek release from personal liability, or from costs for damages or partial indemnity, by either subscribing to the several employés' liability insurance companies or by wide-spread attempts to evade their responsibilities under the law by inducing the workmen to contract themselves out of the act. Several other methods of securing release from liability have been devised, the most prominent of which, perhaps, is the length to which defendants go in the appeal courts.

The employés of most American railroads are incessantly confronted with petitions for charitable contributions in aid of their fellow-workmen and companions overtaken by misfortunes, which almost always involve others dependent upon them for the necessities and comforts of existence. Such appeals to people too generally living in the presence and under the dread of the embarrassments and evils incident to interrupted wages can seldom be ignored, though often their alms frequently materially encroach upon the previously mortgaged incomes of men engaged in pursuits than which few are more exacting, and that taxed their abilities and time to such an extent as precluded the possibility of supplementing through extra labor wages reduced by competition to barely living rates. The higher officials of the company are constantly importuned in the same direction, and the contributions they feel constrained to make sometimes reach considerable sums. The recipients of such charity naturally experience a sense of humiliation; their self-respect is lowered, and upon recovery from sickness or injuries they too frequently resume their occupations handicapped by the discontent and restlessness of debtors, to whom such condition is too novel and harassing to be borne with equanimity. From this results constant anxiety to better their condition, and it

prepares them for any and all alliances or changes that promise increased wages, and makes them easy dupes of the designing and turbulent.

One result of the indifference of railroad managements toward their subordinates has been to array against them agencies most potent in fermenting discontent—secret societies, brotherhoods, and similar organizations; for it is a notorious fact that these mainly owe their success and strength to the assistance and relief they hold out to their members and their families in sickness, disablement, and death. Thrown upon his own resources, the man who has constantly before him the perils of his vocation and the misfortunes that would result from inability to earn wages, naturally enrolls himself in any organization that promises the needed protection. Constantly confronted with the history and with comparisons of the grievances of his fellow-members, and without motive or cause for attachment to his employers; perhaps, unconsciously, feelings of discontent and ill-will arise, and naturally he meets any reduction of wages or suspension from labor with outraged feeling, and often with violent actions born of long though secret hostility, where there should have been but fraternity and good-fellowship of affiliated interests. That this is no sentimental picture, many of the actors of the great labor-strike of 1877 testify. On more than one line was the statement afterward repeatedly made by railroad men, that had it not been for the protection from want afforded by the Locomotive Brotherhood and other kindred organizations, whose influence in antagonism to capital was so potently felt in that struggle, and which protection they had repeatedly besought their officers to inaugurate for them, they would never have joined or been influenced by those organizations.

To recapitulate the many serious disadvantages and losses, direct and indirect, suffered by our railroads through strained relations with their employés, though recognized and felt with anxious solicitude by their executive and administrative officers, would little interest the general public; nor, indeed, as a rule are railroad investors apt to give serious attention to what they consider matters of administrative detail beneath their notice, until, at last, they force themselves into prominence by threatening their profits or speculations. But the unparalleled rapidity with which railway, mining, and manufacturing industries dependent thereupon have sprung into existence in America in the last three decades, calling for an ever-increasing supply of labor skilled in the manipulation of coals and metals, and their products, has had the effect of directing the attention not only of those immediately or by contiguity interested, but also of the general public, to all that pertains to the welfare of workers in that field. While labor agitations and strikes do not now, perhaps, exercise graver influences for good or ill over those pecuniarily interested than they have always done, the publicity given to such movements by a press eager for news and ex-

citing incidents, and the avidity with which political manipulators seize upon opportunities afforded by the agitation of bodies of men, wisely or unwisely, eager to secure material advantages through any immediately effective agency, unitedly operate in bringing into prominence those accidents and losses of life and property inseparably connected with mining and railroading. In the United States the operatives of railroads have, as already stated, been too generally left to their own resources, though now public opinion is gradually forcing upon employer and employé a recognition of the duty of securing both the laborer and his dependents from the consequences incident to his occupations. Where humanitarian considerations are not governing, those of self-interest are more potential, and the increasing frequency of successful suits for damages on the one hand, and on the other the constantly accumulating difficulties of earning a livelihood without steady, uninterrupted occupation incident to increasing population, are unitedly forcing this question to the front.

Recurring to the inquiry, by what means within reach substantial improvement can be effected in the condition of railroad servants at least cost, and with a minimum risk to capital and a maximum of devotion to the service, we have seen, by means of an illustration, by what simple and inexpensive means partnerships, almost ideal, have been effected by private enterprise in Europe, and such illustrations might be multiplied indefinitely.

Further study of the methods of foreign railroads in dealing with this subject will show that their efforts (which must be successful, for labor disturbances are very exceptional abroad) have almost uniformly taken the form of benevolent societies, organized, or contributed to and fostered, by the railway managements.

The practical utility of such organizations has there been exemplified for many years. In their various forms (when established under the auspices of responsible authority) they meet many of the necessities of the railroad employé: they provide means for avoiding insurance organizations unworthy of confidence; lessen the risk of insolvency and loss of premiums paid; offer convenience, certainty, and regularity in making payments, and give a fixed and definite rate of assessment and compensation, in place of the uncertainties of co-operative associations, lodges, or brotherhoods, in which many members, though taxable on the death of a fellow-member, evade or refuse to respond to assessment.

Among such associations may be instanced the London and Northwestern Railway Insurance Society and Superannuation Savings-Bank; the Friendly or Providence Society and Mutual Guarantee Fund; the Great Northern Railway Benevolent Institution; the Great Western Railway Superannuation Society — all of England; the benevolent institutions of the Chemins de Fer du Midi of France; and a host of other Continental societies, all having for their objects the succor of

railroad employés and their families in sickness or grave infirmities, or wounds entailing incapacity for work, old age, death, and the promotion of culture and habits of thrift and industry. Many of these societies reach further than mere relief, and provide for the moral and intellectual training and entertainment of their members and their children; aid them in acquiring and embellishing properties, and exercising a controlling influence in the councils of the nation in all matters of legislation affecting the working-men; they have elevated their members' conditions from servitude and poverty to independence and prosperity, and in other ways have exercised a paternal care and supervision over their interests. Early recognizing in such societies an agency potent to improve alike the secular estate and the moral, physical, and intellectual condition of their employés, and also understanding that easy circumstances and contentment develop increased usefulness in all walks of life—in none more so than in railroad service—the English railways, by liberal and judicious encouragement of such enterprises, have practically relieved themselves from many onerous burdens under which nearly all our companies are still suffering.

[*To be continued.*]

THE PRESENT ASPECT OF MEDICAL EDUCATION.

By WILLIAM GILMAN THOMPSON, M. D.

THERE is no branch of education which attracts so little public interest and support as proper medical instruction, yet no one would gainsay the necessity that, if there are to be physicians at all, the community should be guaranteed that they have been most thoroughly trained.

It is not so very long since an air of mystery, which no laymen would attempt to penetrate, enveloped the art of medicine. It required generations to separate medical practice from alchemy, astrology, and the search for the elixir of life. The traditions and influence of Hippocrates and of Sydenham lasted well into the past century, and down to 1750 almost all of the scanty medical literature was in Latin, and the gradually accumulating facts of observation were still too little systemized to be weaned from an admixture of the most unreasonable speculation and pseudo-philosophic discussion. As late as 1784 the condition of medical education in the United States was most rudimentary, and for some time thereafter dissections of the human body could only be made by stealth.* The functions of physician, nurse, apothecary,† and often, too, of pastor, farmer, dentist, and

* See McMaster's "History of the People of the United States," vol. i, pp. 27–31.

† "Life of Dr. John Warren," p. 314.

veterinary surgeon, were frequently combined in one person in the early part of the present century.

What a contrast appears to-day! Popular medicine and hygiene are becoming everywhere the fashion. Public sentiment and action are aroused in regard to all manner of sanitary and curative measures. When men of distinction are ill, the conditions of their pulse, temperature, and respirations are telegraphed all over the civilized world, to be read at the breakfast-table in the morning newspaper. Their medicines and their doses are minutely described; diagrams of the course of a bullet, or startling pictures of microscopic sections of tumors, or views of cholera-germs, appear in our daily papers; and in the most popular family magazines we read articles upon the "anatomy of the brain," or "how to trap a soil-pipe." We have a mother's magazine devoted to improvements in baby-feeding and the scientific development of the infant mind. The book-stores abound in popular works upon every medical topic, from the subject of singers' sore throats to the treatment of sea-sickness, consumption, or the opium-habit. A great deal of all this, especially the newspaper medicine, is fostered by a maudlin craving for every detail of that which is exciting or horrible. It is to cater to the same kind of feeling that newspapers describe how many lumps of sugar a condemned murderer took in his coffee on the morning of his hanging. The germ-theory, too, has given a great impetus to popular medicine.

The germ appeals to the average mind: it is something tangible; it may be hunted down, captured, colored, and looked at through a microscope, and then, in all its varieties, it can be held directly responsible for so much damage. There is scarcely a farmer in the country who has not read of the germ-theory. A cow-boy in Arizona was shot dead in the saddle recently by a comrade for the insult implied by calling him a "d——d microbe"!

Still, a great deal of this popular medical talk and instruction is the outcome of an earnest desire to learn to alleviate the growing evils of heredity and environment, especially in overcrowded cities. The importance of a universal knowledge of, and attention to, the laws of physiology and hygiene is becoming more and more appreciated,* and the elements of these subjects are taught in the public and private schools. The mental training to be acquired through the observation of biological and physiological facts is recognized as being of the greatest importance, and laboratory courses of instruction in these studies are already introduced in many of our colleges and universities side by side with the classics. There is a wide-spread popular interest in the thorough training of nurses for the sick, and in such practical and beneficial work as the establishment of diet-kitchens for the sick poor, and sanitary reforms of all kinds. We have "Sanitary Protective Leagues" and "Sanitary Aid Societies," composed princi-

* See Spencer on "Education," chap. i, p. 76, "What Knowledge is most worth."

pally of laymen, and instruction in "First Aid to the Injured" is given to policemen, firemen, and enthusiastic young ladies! Very many laymen also interest themselves most liberally in the establishment and management of hospitals and dispensaries.

All these activities, directed toward improving the public health and alleviating sickness and suffering, are most gratifying and commendable, and call for increasing thoroughness in methods of educating physicians, for, without the co-operation of the public with scientific men who devote their lives to the study of these subjects, much benevolent energy as well as time and expense are wasted or misapplied. Is it not clearly of vital moment that the public for its own protection should see to it, by legislation or other means, that the medical schools of this country are of the highest order? A dozen well-trained and properly qualified physicians will be of vastly more benefit anywhere than a hundred "M. D.'s" who have slipped through some of our so-called medical "colleges" in the easy manner that is still quite possible. It is disgraceful, and yet it happens constantly, that men are graduated by prominent medical schools or colleges in this country without ever having listened to an abnormal heart-sound, seen a case of measles, or been present at a confinement. "But," it is asked, "why should the general public take any interest in medical education? Why not let doctors manage their own 'shops,' as they always have done, unaided by public support?"

The answer is that, so long as a medical college is dependent entirely upon the fees of its students for support, the highest educational good can not be attained. The question concerns endowment. A review of a few facts and statistics will demonstrate this need.

The medical profession in the United States, like many branches of industry, is at present suffering severely from over-repletion. There are more doctors, in proportion to the population, than in any other country in the world. The laws of supply and demand tend to lead many men toward those schools where they can soonest secure their diplomas with least expenditure of time and money (and too often of energy). The schools become overcrowded, and new ones spring up with alarming rapidity. A century ago, with a population of 3,000,000, there were two medical schools. To-day, with a population of 50,000,000, we have eighty-seven medical schools,* distributed through twenty-eight States and the District of Columbia. Of these schools, thirty-nine have been opened within fifteen years, and twenty-one (or about twenty-six per cent) within five years past. With them are associated over 1,300 instructors (many of whom offer their services gratuitously) and over 10,000 students, while about 3,600 new doctors are annually "turned loose upon the community," as the daily press courteously expresses it. Forty-six per cent of the schools offer only a two-years

* The writer would be understood as referring only to "regular" schools in this article; there are very many others.

course of instruction, three of them offer a four-years course, and the remainder offer, although only few *require*, a three-years course. The inaugurators of the reform of prolonging the course of study were the Chicago Medical College and the schools at Harvard and the University of Pennsylvania. At but few schools is the instruction graded for different years, and students are usually compelled to pay for hearing twice over the same course of lectures in two years. This, with a little dissection, a thesis, and examinations upon the lectures, is frequently all that is required of them before receiving a diploma. Almost all practical work is optional, and, instead of each student being obliged to secure a hospital experience, he is lucky if he obtains an appointment as *interne* after an additional competitive examination for which he has crammed himself full during months of toil over text-books and lecture-notes.

The better class of students feel the inefficiency of this system and so far as possible supplement it by attending small "quiz classes" for recitations and practical work, which are, however, entirely independent of the colleges, and are in no sense obligatory. The success of these small voluntary classes (often conducted by men who are without any official connection with the colleges) in drawing students, who thus incur considerable additional expense, is in itself a severe commentary upon the poverty of the colleges which restricts them from making their own advantages all that they should be.

Such is the system in vogue to-day at a large number of our medical colleges. There are, fortunately, a few where a much higher standard is not only encouraged but required. No wonder that our students, immediately after graduating, go by the hundred to Paris, Berlin, Vienna, etc., where the Government encourages professional schools, laboratories, and scientific bureaus by substantial support and thorough system. They go abroad, partly because it is the fashion, and gives them a sort of advertisement as having done the proper thing, and partly to learn a new and useful language, and study foreign methods of life. But the fundamental reason of their going is that, instead of sitting in a huge lecture-hall with two or three hundred other men, to take notes *verbatim* of a lecture which often might be read in a text-book at home, they can join small classes in which they practically demonstrate every fact for themselves, under the guidance of an instructor.

Lectures have their value, certainly, but it is a relative value which is greatly enhanced by practical teaching. A gigantic picture of a sore throat, hung on the wall of a lecture-hall, is after all far less instructive for a student than looking into the real throat, telling what he sees there, and then looking again, while what he at first omitted is pointed out to him.

There are many demonstrations which can be better made, and many theories which can be more conveniently discussed, in a lecture;

still, it is well to bring a student face to face with at least one patient before intrusting him with a diploma and license to practice at large.

But practical work, at its commencement at least, means increased expense. There must be separate and well-appointed laboratories for chemical, physiological, anatomical, and pathological research, rooms for photography, germ-culture, delicate electrical apparatus, for hygienic and therapeutic demonstrations, for libraries, and for the reception and treatment of many classes of patients at clinics. Moreover, assistant instructors and demonstrators are needed, in order that each student may receive a fair share of personal attention. (At present the classes are so large that candidates for graduation are often unknown by sight even to a majority of their instructors.)

Suppose for a moment that the professors of a medical college put their hands in their own pockets and provide these improvements, as they have already done in some instances to a limited extent. Many students will leave for cheaper and easier colleges, and the fees are likely to fall off so much that professorships having no endowments to rely upon must be abandoned. Thus the lack of endowment is a virtual check upon all growth. Division of labor with a new assistant instructor means division of personal income with him. The expense of maintaining a new laboratory means a further reduction of the professor's income. As Dr. O. W. Holmes wittily says, "A school which depends for its existence on the number of its students, can not be expected to commit suicide in order to satisfy an ideal demand for perfection."* General Eaton (to whose admirable report on medical education† the writer is indebted for many of the statistics of this article) strongly advises that every medical school or college be required by law to procure forthwith an endowment of not less than $300,000.

Strangely enough, in some instances the professors themselves object to the endowment of their chairs, because they fear a sacrifice of their independent methods, or because it seems impossible to secure endowments which would yield as fair incomes as they at present derive from the students' fees. But there is no reason why the students should not continue to pay as they do now, and a certain amount of endowment, required by law, would prevent half a dozen men from forming a new medical college without proper laboratories, apparatus, or facilities of any kind. The experience of the past ten years proves this danger to be a real and increasing one.

The professorships and laboratories once endowed, the professors can be trusted to elevate the standard of medical education very rapidly throughout the country. But there should also be separate State or National Boards of Examiners who alone should have the power of granting licenses to practice medicine, based upon proofs of prac-

* "Boston Medical and Surgical Journal," January 19, 1882.

† "Report of the Commissioner of Education," 1882–'83, clxiii–clxxxiv, 660–672.

tical laboratory and hospital work, and upon the diplomas of only first-class colleges, which latter should be raised to a uniform high standard of merit. Applicants for licenses should be examined, not as to what theories they hold, to what "pathy" they conform, or what text-books and lectures they have crammed, but as to what evidence they can give of personal examination of the human body and personal observation of its ailments and witness of the influence of remedies.* Laymen can render great assistance in these matters (and the gain is ultimately their own) by furthering appropriate legislation, frowning upon quackery and cheap diplomas, as well as by co-operating with the medical colleges in offering freely the use for clinical instruction of all the hospitals and dispensaries which the public support and control. Most valuable opportunities for clinical observation are at present needlessly wasted through lack of this system. To-day the value of income-bearing funds of the eighty-seven medical colleges does not exceed $350,000, which yield an annual income of only about $20,000. It is instructive to contrast with this statement the fact that the one hundred and forty-five theological schools and colleges of the United States have a productive property of $9,500,000, and an annual income therefrom of nearly $600,000!

Of our eighty-seven medical schools, forty-two are associated with general colleges or "universities," but the connection is usually merely nominal, and no means of support are derived from the parent college. The precarious footing upon which many of these institutions stand is to be inferred from the fact that no fewer than fifty-one other medical colleges founded in the United States within a century have collapsed and vanished.†

It is a grave misfortune to have so many medical colleges as now exist, for it is a farce to attempt to educate medical students away from the hospitals and dispensaries which only the largest cities furnish in abundance. The tendency to-day in all branches of education —from the Fröbel Kindergarten system to the study of engineering— is more and more toward placing practical work and personal observation before tradition and theoretical instruction. Surely medical education must not be left behind in facilities.

There are many encouraging signs of speedy improvement in this matter. There is a growing dissatisfaction with the old system. The percentage of medical students who are graduates in letters or science is constantly increasing. At present they number nine per cent, and they have frequently had the advantage of a year or two of biological, physiological, and chemical practice before entering the professional school. The number of such students at the Medical College of the University of Pennsylvania has doubled in the past six years. The

* The State Board of Health of Illinois is a praiseworthy pioneer in this field.

† "Conspectus of the Medical Colleges of America," 1884, 1885. Illinois State Board of Health.

number of medical schools which require some sort of preliminary examination for admission is also increasing. A great deal is expected of the Johns Hopkins Hospital and Medical College (which are handsomely endowed) when they shall be in operation. Several chairs have been endowed in the Medical College of the University of Pennsylvania. Mr. Vanderbilt's recent magnificent gift was for a lot and building and not for endowment, but the donor set the excellent example of aiding an already tried institution instead of launching a new one among the many which are at present struggling to float. The work accomplished in the past ten years by physicians themselves through their various societies and organizations in exposing quackery, injurious patent medicines, malpractice, and bargaining in diplomas for which no study has ever been expended, has revealed and corrected an enormous amount of abuse and crime, notwithstanding the very tardy legal and popular support which has attended these efforts. Our great need is a little more system and concentration of energy, or a diversion of some of the wide-spread public interest in general medical topics toward securing and demanding the most thorough medical education for every one who seeks to become a physician. This will be of incalculable service to the entire country; and endowments, whether by State legislation or private bequests and subscriptions, combined with State or national supervision of licenses to practice, will so far advance the thoroughness of work at home by making it independent of large or small classes of students, that we may hope before long to invite foreign students to learn from us how to take the lead in medical education.

INSECT FERTILIZATION OF FLOWERS.*

By Dr. W. J. BEHRENS.

OF insects the Coleoptera, the Lepidoptera, the Diptera, and the Hymenoptera are the orders most concerned in the fertilization of flowers. More rarely, fertilization is effected by one or other species of Hemiptera, Neuroptera, and Orthoptera, but these are not of sufficient importance to demand further attention here. We shall therefore confine our remarks to the orders constituting the former group, and consider the various physical peculiarities by which insects belonging to them are enabled to effect the end in question. Such peculiarities chiefly take the form of *special structures* (invariably confined to the head), *by means of which the insects are enabled to reach and abstract the honey* contained in the flower. We shall also have to consider the *organs concerned in the transport of the pollen.*

* From "Text-Book of General Botany," by Dr. W. J. Behrens, of Göttingen. Translation from the second German edition. Revised by Patrick Geddes, F. R. S. E. Edinburgh: Young J. Pentland, 1885.

The order Lepidoptera comprises many species of great importance in effecting the process of fertilization. Their large wings are well adapted for rapid flight from flower to flower, and their long proboscis enables them to reach the honey even when the nectary lies at the bottom of a very long and narrow corolla-tube.

The position assumed by the butterflies when engaged in abstracting the honey deserves notice. The wings, which during flight flutter to and fro with a rapid motion, are folded together perpendicularly over the body, in which position they are maintained so long as the insect remains poised on the flower (Fig. 1). The butterfly is thus enabled more readily to escape detection by its many enemies (e. g., birds) than if, when resting, its brilliant wings were outspread. The under surface of the wings is usually of a much less striking color than the upper, and consequently does not prove so attractive. It even happens in many instances that butterflies only visit such flowers as are of the same color as their own wings, this precaution, of course, rendering detection extremely difficult. Many blue butterflies show a marked preference for blue meadow-flowers, while in the Alps the scarlet lilies and many of the orange-colored *Compositæ* are visited almost exclusively by butterflies of like hue. The moths, while extracting honey, do not assume a position similar to that of the butterflies, but hover over the flowers, their wings rapidly vibrating meanwhile.

FIG. 1.—A BUTTERFLY (*Hipparchia Janira*) at rest on a cluster of flowers; natural size.

The butterflies are excellent honey-hunters, because, as already said, their proboscis is very highly developed. It arises from the head midway between the eyes (A, Fig. 2), and frequently exceeds the entire body of the insect in length. When not in use, it is kept coiled up like a watch-spring (I, II), but can be uncoiled at will, and thrust deep down into the nectary of a flower. The proboscis is hollow, and the honey is sucked up by the extreme tip.

In the butterfly the proboscis is the only part of the mouth that is fully developed. In many insects the mouth is very complicated in structure; but in the butterfly a number of the parts are almost entirely suppressed. The *labial palpi* (I, II, III), however, are usually pretty well marked. They are long and narrow, and are densely covered with hairs. To these hairs the pollen adheres, while the butterfly is engaged in sucking the honey, and by them it is carried to the stigma of the next flower the insect enters.

The proboscis is usually from three to seven centimetres long, but in many tropical moths it attains a length of over twenty centimetres. It is by the great length of their proboscis that many butterflies are enabled to suck the honey from flowers having very long and narrow corolla-tubes, where it would be quite inaccessible to other insects. We need scarcely say that this feature is a great advantage to the butterfly order, for it means that they have the monopoly of the honey of flowers with a long, tubular corolla. The honeysuckle (*Lonicera Periclymenum*, see Fig. 3) is a good native example of a flower with a tubular corolla, in which the nectary, *a*, is so situated as to be beyond the reach of the various bees and butterflies with short proboscides, likely to be attracted by it in the daytime. In this case the honey is entirely reserved for one of the evening moths (*Sphinx ligustri*) which possess a proboscis of almost exactly the same length as the corolla of the flower—i. e., about forty millimetres. Attracted by their fragrance, the insect will hover over a cluster of flowers for a time. Finally selecting one, it uncoils its long proboscis, thrusts it deep into the innermost recesses of the corolla, and, at its leisure, sucks the sweets denied to less fortunate members of its kind.

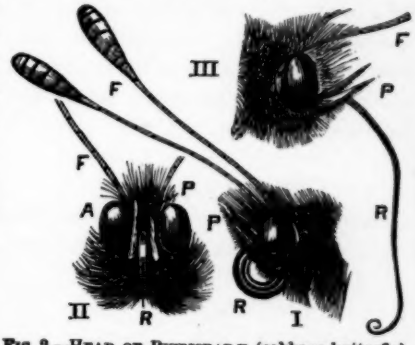


FIG. 2.—HEAD OF PIERIS RAPÆ (cabbage-butterfly), four times enlarged. I, side view, showing the proboscis coiled up. II, front view of the same. III, side view, showing proboscis uncoiled. *R*, proboscis; *P*, labial palpi; *A*, eyes; *F*, antennæ.

FIG. 3.—FLOWER OF HONEYSUCKLE (*Lonicera periclymenum*), frequented by privet hawk-moth (*Sphinx ligustri*), natural size. *A*, nectary; *B*, entrance to the throat of the corolla.

As fertilizers the beetles are not so important as the butterflies and moths. Only a small proportion pay regular visits to flowers, the greater number deriving their food from quite other sources. Many species which do frequent flowers only effect injury, devouring, as they do, some of their most important organs—e. g., the stamens or the ovary. Others, however, and especially those whose small size admits of their creeping into the interior of the flower, frequently promote cross-fertilization, the viscid pollen adhering to the general surface of their body, from which it is brushed off by the stigma of the next flower they enter. Such flower-beetles as *Anthrenus*, *Meligethes*, *Malachias*, and certain smaller sorts, are extremely useful in this way.

In other species *certain parts of the body* are specially adapted for obtaining food from flowers. Thus, in the crown-beetle (*Cerocoma*

Schæfferi, Fig. 4, I, II), the middle of the antennæ are characterized by very strong and well-defined expansions, and are partly covered with hair. The palpi are very long, and the tongue is provided with two tufts of hair. These form together a large yellow crest on the anterior portion of the head (Fig. 4, II). In midsummer this beetle is occasionally to be met with on the flower of the milfoil and corn marigold. If one of these beetles be caught and examined with a lens, the crest is usually found to be covered with a multitude of little yellow pollen-grains.

Among the long-horned beetles the *Lepturidæ* are specially well adapted for procuring food from flowers. The anterior part of the

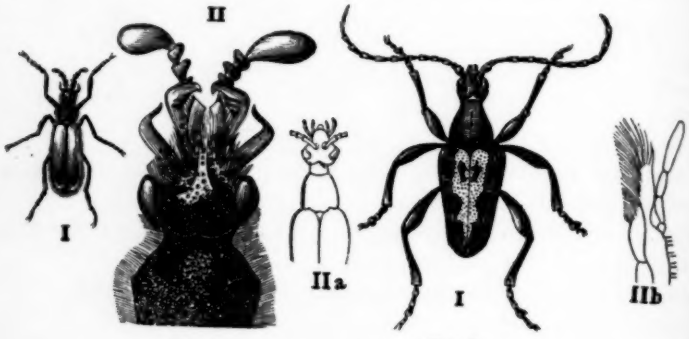


Fig. 4. Fig. 5

Fig. 4.—Crown Beetle (*Cerocoma Schæfferi*). I, beetle, natural size. II, head, ten times enlarged. Fig. 5.—Longicorn Beetles: I. *Pachyta octomaculata*, three times enlarged. II. *Leptura livida*: *a*, head, natural size; *b*, labium.

body (head and thorax) is narrow and elongated, so as to enable the insect to push its way pretty deeply into the interior of the flower. The mouth-parts are well developed, and stand straight forward from the head. The labium is usually hairy, and is thus extremely useful in extracting honey (Fig. 5, I, II).*

Compared with the beetles, Diptera or flies take a very prominent position as promoters of cross-fertilization. One great advantage which they have over the former class is their power of free and rapid motion. While the beetles are almost without exception compelled to adopt a slow mode of locomotion, the movements of the flies are among the most rapid known in the insect world. The number of native species of Diptera is very large; of those which frequent flowers we shall here consider but a few (Figs. 6–10). One of the largest and most rapid flying of the Diptera is the humble-bee fly (*Bombylius major*, Fig. 6). In this species the proboscis, which is situated on the anterior portion of the head, is of considerable length, so that the insect can reach the honey even when it is secreted some way down the

* The rest of the *Lepturidæ* live for the most part in or on wood. In contrast to the species just described, the thorax is broad, the mouth situated toward the under side of the head, and the maxillæ either very slightly hairy or totally destitute of hairs.

corolla-tube. The manner in which *Bombylius* hovers over a flower while extracting the honey closely resembles that already described as characteristic of the moths among the Lepidoptera.

The *Empidæ* (Fig. 7) are easily distinguished by the peculiar formation of the head and proboscis. The latter is not directed forward, but almost perpendicularly downward, and the head itself is round; the whole thus bearing some resemblance to the long-beaked head of a crane. Many of the *Syrphidæ* are also honey-suckers. In structure they resemble the common house-fly more than the Diptera we have

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 6.—Humble-bee Fly (*Bombylius major*), natural size. Fig. 7.—*Empis livida* (after Meigen), four times enlarged. Fig. 8.—*Syrphus*, natural size.

just considered. The posterior part of the body is mostly distinguished by a number of bright and dark colored bands and specks. As typical examples we may mention the large *Syrphus* (Fig. 8), the allied *Eristalis tenax* and *arbustorum* (Fig. 10), and the cone-fly (*Rhingia rostrata*, Fig. 9). The latter may easily be recognized by its peculiar proboscis, which is kept coiled up under a small conical projection on the anterior part of its head. The sucking apparatus of the Diptera consists of a suctorial proboscis, resembling in a general way that of the common house-fly. It is tubular, short and thickened at its extremity, so as to form a disk, upon which are furrows and hairs. It is by means of this disk that the honey is taken up. The proboscis of the Diptera being almost always short and blunt, they can only extract honey from such flowers as have an open corolla. Insects of this order, then, need only be sought for on flat flowers, and there indeed they may be seen on any sunny day, rapidly creeping about, and greedily imbibing the nectar. The *Umbelliferæ* are special favorites with them, the nectar being found on the disk in the center of the flower, which can very easily be reached. The Diptera are never found on flowers with long corolla-tubes. Only such forms as the humble-bee flies, *Syrphidæ*, *Empidæ*, and a few others, have a proboscis large enough to enable them to obtain honey from flowers of slightly tubular form. The proboscis of *Bombylius* (Fig. 11, I) is about one centimetre long. It is strong and stiff, cleft at the extremity, B, and thickly beset with

Fig. 9.

Fig. 10.

Fig. 9.—Cone-fly (*Rhingia rostrata*), natural size. Fig. 10.—*Eristalis arbustorum*, natural size.

hairs. Certain other structures entering into the formation of the mouth (e. g., the lip, A, the mandible, D, and the maxillæ, C C) almost equal it in length. The cone-fly (*Rhingia rostrata*), in common with many other broad-headed flies, possesses the power of coiling up its proboscis, the length of which is about twelve millimetres (Fig. 11, II–IV). That anterior portion of the cone-fly's head (II) is prolonged forward so as to form a sort of beak (S). When not in use, the proboscis is kept coiled up beneath this prolongation. When required, the extremity of the proboscis (B III) is first inclined downward, and the organ is next suddenly shot out to its full length. When fully extended the proboscis projects far beyond the beak-like anterior portion of the head (IV). The extraction of the honey is effected by means of the cleft tip (B). The cleft extremity is used in sucking.

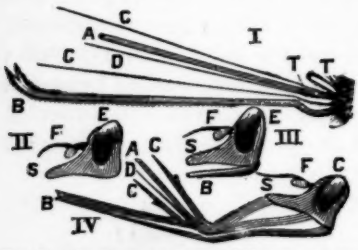


FIG. 11.—STRUCTURE OF THE MOUTH OF THE DIPTERA. I, humble-bee fly; II–IV, cone-fly. II, side view of head, with the proboscis coiled; III, do., the proboscis beginning to uncoil; IV, do., completely uncoiled. *E*, eye; *F*, antennæ; *S*, beak; *T T*, palpi; *B*, extremity of proboscis; *A*, lip; *D*, mandible; *C C*, maxillæ.

We have already seen that many flowers are exclusively visited by Lepidoptera, their honey not being within the reach of insects belonging to any other order. Such, for instance, are honeysuckle and privet. Very few flowers, however, are frequented solely by Diptera; for the length of the proboscis, even in those Diptera in which it is best developed, is attained, if not surpassed, by many of the Hymenoptera (humble-bees, honey-bees, etc.). The latter class, therefore, share with the Diptera the privilege of frequenting certain species of flowers. We shall now pass on to consider them for a little.

Of all insects the Hymenoptera (*bees* and *wasps*) are, on account both of their physical structure and their peculiar instincts, the best adapted for the task of extracting and collecting honey from flowers. The species comprised in this order, and more especially the bees, are all characterized by a superior share of intelligence, not only as honey-hunters, but in many other respects. Their mode of living together in large, well-ordered communities, presided over by a queen, has long been a subject of marvel and of study. Out of the wax, which exudes at the joints of the abdominal segments of their bodies, they construct a "comb," consisting of a number of united cells. The cells when finished are filled with honey or "bee-bread," a substance composed of a mixture of honey and pollen. This bee-bread forms the food upon which the young larvæ are reared.

The bees are the greatest promoters of cross-fertilization, not only among the Hymenoptera, but among all insects whatsoever.

Over two hundred species of our native bees (*Apidæ*) are known as frequenting flowers, the most familiar being the common honey-bee

(Fig. 12). The task of collecting and storing honey is performed exclusively by the neuters (workers). The humble-bees do not fall far short of the honey-bees in the assiduity with which they frequent flowers, and they surpass the latter in size and in length of proboscis. Our most common species are the earth humble-bee (*Bombus terrestris*, Fig. 15), the garden humble-bee (*Bombus hortorum*), the moss-bee (*Bombus muscorum*), and the stone-bee (*Bombus lapidarius*). Very

FIG. 12.

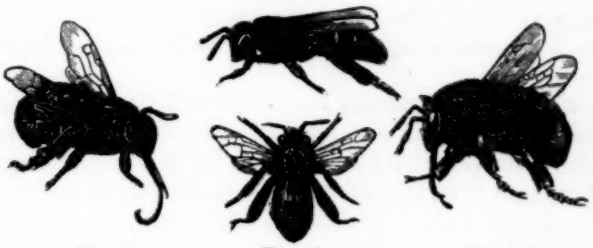


FIG. 13. FIG. 14. FIG. 15.

Hymenoptera.—FIG. 12.—HONEY-BEE (*Apis mellifica*), queen, natural size. FIG. 13.—HAIRY-BEE (*Anthophora retusa*). FIG. 14.—EARTH-BEE (*Andrena Schrankella*). FIG. 15.—HUMBLE-BEE (*Bombus terrestris*).

similar to the humble-bees in appearance and structure are the hairy-bees, one of which is shown in Fig. 13. They are readily distinguished, however, as we shall presently see, by the formation of the hind-legs. In Fig. 14 we have a sand-bee (*Andrena Schrankella*, a species representing one of the largest genera), which may be seen in early spring on catkins and other spring flowers.

We have already said that, over and above their high intelligence, bees are remarkable for having certain parts of their body specially modified in connection with the acquiring of honey and pollen. We must therefore further consider the structures concerned in effecting this end, viz., the *suctorial apparatus* and the *apparatus for collecting pollen.*

The suctorial apparatus is in most bees developed in very great perfection. In many (Figs. 13–15) the proboscis is of considerable

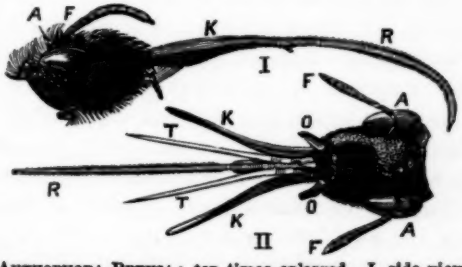


FIG. 16.—HEAD OF ANTHOPHORA RETUSA; ten times enlarged. I, side view; II, top view. *R*, tongue; *K*, maxillæ; *T*, labial palpi; *O*, mandibles; *T*, antennæ; *A*, eyes.

length, in some cases being as long as the body. It consists (Fig. 16) of the long vermiform tongue (R) (as in the butterflies), the upper

surface of which is mostly well provided with oblique rows of long bristles. The maxillæ (K) and part of the labial palpi (T) are modified into flat, leaf-like, linear processes, which are arranged around the tongue (R), and thus complete the suctorial proboscis. While, therefore, the suctorial apparatus of the butterfly consists simply of a coiling or suctorial tongue, it must be noted that in the bee other parts are concerned in the formation of the tubular sucking apparatus. In many bees, besides, the tip of the tongue is peculiarly modified, so as to enable the insect to taste the honey before beginning to collect it, an arrangement by which honey of unpleasant taste can be rejected.

Apparatus for collecting Pollen.—Of all insects the bees alone have certain parts of their body specialized for the collection of pollen. The structures developed for this end are in their way perfect. They may be found either on the ventral surface of the posterior portion of the body or on the legs. Accordingly, bees may thus be divided into two groups: 1. Bees having structures for the collection of pollen on the ventral surface of the body; and, 2. Bees having such structures on their legs. To the first group belong the mason-bees (*Osmia*) and the leaf-cutter bees (*Megachile*). In these species the ventral surface of the abdomen is furnished with long, stiff, retroverted hairs, by means of which the pollen is brushed from the anthers as the insect passes in or out of the flower. The grains get entangled among the hairs, from among which the bee afterward dislodges them by means of its legs.

This contrivance is admirably adapted for obtaining pollen from flowers having a flat corolla, but not for such as have the anthers concealed in a deep tube. Our most highly developed bees (humble-bees, honey-bees, etc.) have therefore apparatus suitable for collecting pollen from flowers of all shapes.

The most highly developed bees collect the pollen on the hind-legs, but all do not possess the structures adapted to this purpose in like perfection. Fig. 17 represents one of the hind-legs of the hairy-bee (*Anthophora retusa*, compare Fig. 13); we here see the trochanter (R), the femur (S), the tibia (T), the tarsus (P), the four other joints of the foot (F), and, finally, the two claws (K). The tarsus (P) and the tibia (T) bear the structures by which the pollen is collected; both are seen to be laden with many grains of pollen (left white in the illustration). The tibia and tarsus are broad and flat, and are thickly covered with hairs. The pollen is brushed from the anthers by means of the hairs on the tarsus (P), and is afterward transferred to those of the tibia (T), where they are suffered to remain until the hive is reached. In the humble-bee (Fig. 18, *Bombus terrestris*) the same arrangements are carried out in yet greater perfection. The tibia (T) is smooth on the outer surface, while the inner surface is covered with long, stiff hairs, which form with the surface of the tibia a little depression, into which the pollen is brushed by the short hairs of the tarsus. In the honey-

bee the arrangements are similar to those just described, but the hairs of the tarsus are much better adapted to their purpose (Fig. 19). They are disposed in eight or nine rows, while in the humble-bee they are distributed irregularly. By this regularity of arrangement the honey-bees are enabled to brush the pollen from the anthers far more effect-

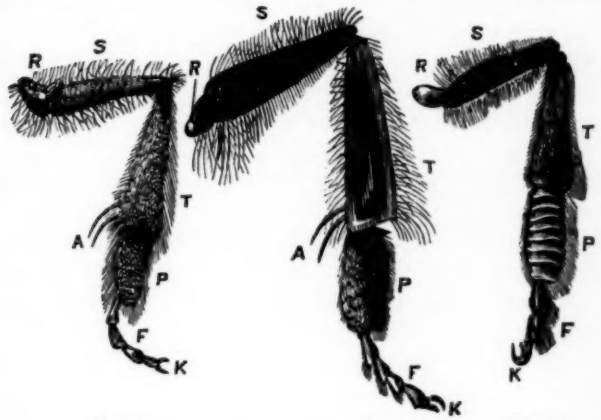


Fig. 17. Fig. 18. Fig. 19.

Hind-Legs of Bees, showing structures for collecting pollen. Fig. 17.—Hairy-bee, four times enlarged. Fig. 18.—Humble-bee, four times enlarged. Fig. 19.—Honey-bee, five times enlarged. *R*, trochanter; *S*, femur; *T*, tibia; *A*, prickles on tibia; *P*, tarsus (pollen-brush); *F*, other segments of the foot; *K*, claws.

ually. The pollen, once removed from the antlers, is next transferred to the hairs, or to the surface of the tibia, to which, being viscid, it readily adheres. After the process of collecting has been carried on for some time, the pollen forms thick yellow masses, which completely envelop the legs. Laden with the fruits of its toil, the insect wings its way homeward, and deposits them in the bee-hive.

While our native flowers are many of them entirely dependent on insects for the transference of pollen, the process of cross-fertilization is, in many tropical species, always effected by birds, which visit the flowers on account of their nectar.

In America the humming-birds (*Trochilidæ*, Figs. 20–22) and in Africa the honey-eaters (*Cinnyridæ*) are the great promoters of cross-fertilization.

The honey-birds are found in the tropical regions of Africa, Asia, and Australia, while the humming-birds belong to tropical and South America. The former suck the honey with their long, tubular tongue, which is brush-like at the tip. Their relations to flowers have not yet been sufficiently investigated, but a good deal is known respecting those of humming-birds.

The humming-birds are small (the largest species attaining to about the size of a swallow, the smallest not much larger than a humble-bee) and of delicate structure. They are famed for their magnificent plumage, which almost always displays metallic tints. Their flight does

not resemble that of any of our native birds, being maintained by rapid vibrations of the wings, which enable them to remain apparently motionless in one spot for a considerable time. Their passage from place to place is effected by a series of rapid darts, almost too swift for the eye to follow. Their flight might perhaps be best compared to that of a moth. Like these insects, the humming-birds hover for long over a flower, sipping the honey with their long, thin bill, and in other particulars also—in color and form, for example—humming-birds and moths offer some remarkable parallels. Representatives of each may be found, to distinguish between which needs a close scrutiny, and which, when on the wing, might perplex the best observer. To all outward appearance the humming-birds are birds when at rest, insects when in motion.

The tongue of the humming-bird is admirably adapted for extracting the honey from flowers, being really a suctorial tongue in the truest sense of the expression. Long and tubular, often bifid and hairy at the tip, this organ serves to catch the insects that may be concealed in the flower (Fig. 22, I). The beak is long, thin, and pointed; the upper

FIG. 20. FIG. 21.

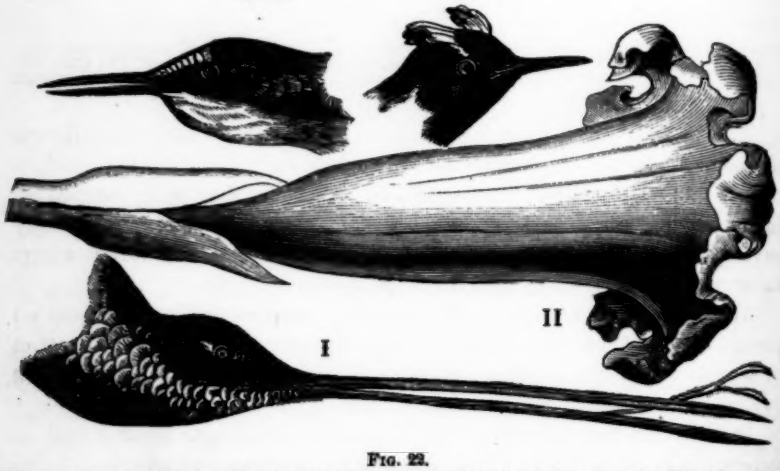


FIG. 22.

HUMMING-BIRDS. FIG. 20.—*Heliothrix aurita*, three fourths natural size. FIG. 21.—*Heliactinus cornutus*, three fourths natural size. FIG. 22.—I, SWORD-BEAK (*Docimastes ensifer*). II, A flower visited by it for its honey (*Datura*); three fourths natural size. (After Brehm.)

jaw closes over the edges of the lower jaw, thus forming a kind of tube incasing the tongue. In almost all species the beak is straight or very slightly curved (Figs. 20–22); in the sickle-beak alone (the *Eutoxeres aquila* of the equator, for example) it is sickle-shaped. The length of the beak varies in accordance with the length of the corolla-tube of the flowers habitually visited by the different species. In the *Heliactinus cornutus* of Brazil (Fig. 21) it is 1·5 centimetre long, in the *Heliothrix aurita* of Minas-Geraës in Brazil (Fig. 20) about two centimetres. The longest beak among the humming-birds is that of the

Docimastes ensifer of Venezuela (Fig. 22, I), that of the female being eight, of the male ten centimetres long. Fig. 22, II, shows a flower of the datura species freqented by the last-named; we here see how the length of the beak and that of the corolla correspond.

We thus see that in the tropics there are not only wind and insect fertilized flowers, as with us, but also certain which are bird-fertilized, i. e., plants in which the transference of the pollen is effected by humming-birds.

ORIGIN OF MAN AND THE OTHER VERTEBRATES.

By Professor EDWARD D. COPE.

THE early part of this century saw the establishment of most of the fundamental principles of the science of physics, especially as applied to astronomy. A few decades later saw the science of chemistry emerge from the empirical and enter the philosophical stage. It has been reserved for the second half of the century to witness the discovery of the facts and principles of the history of life on the earth. The public mind is gradually awakening to the fact that the grandest truths of creation are being placed within their reach by the researches of contemporary science, and that the knowledge of the manner of the origin of the human race is no longer withheld from us.

The study of the fossil remains of animals has revealed an immense number of forms of life which in former ages have peopled the world. The study of geology has shown that the history of our planet is marked by successive deposits in water, which have become beds of rocks. The relation of these beds to each other gives us the relations of the animals and plants whose fossil remains they contain. Thus we have obtained a consecutive history of life from its early appearance to the present day. Before the doctrine of evolution was understood, the successive populations that filled the successive periods were supposed to have been the products of special creations. Now it is believed, with the best of reason, that all forms of life have been produced by changes of structure which arose in the course of descent, the one species coming from the other; and that interruptions in the series of species from older to later periods are simply due to the absence of the means of preserving their remains at certain times during the course of the history of the world. These interruptions indicate periods of dry land, since fossils are not preserved unless they are excluded from the air by a covering of water or of mud.

It is one of the peculiar advantages of the North American Continent to the scientist that the geological structure of its great interior is comparatively simple, so that its history can be easily read. It fol-

lows that the history of the succession of life is recorded with the same regularity, and may be read by those who will bestow the necessary labor upon it. Those who have, during the last ten years, devoted themselves to this study have been rewarded by the discovery of the course of development of many lines of animals, so that it is now possible to show the kind of changes in structure which have resulted in the species of animals with which we are familiar as living on the surface of the earth at the present time. Not that this continent has given us the parentage of all forms of animal life, or all forms of animals with skeletons, or vertebrata, but it has given us many of them. To take the vertebrata, we have obtained the long-since extinct ancestor of the very lowest vertebrates. Then we have discovered the ancestor of the true fishes. We have the ancestor of all the reptiles, of the birds, and of the mammals. If we considered the mammals, or milk-givers, separately, we have traced up a great many lines to their points of departure from very primitive things. Thus we have obtained the genealogical trees of the deer, the camels, the musk, the horse, the tapir, and the rhinoceros, of the cats and dogs, of the lemurs and monkeys, and have important evidence as to the origin of man. We have the primitive mammals from which all these kinds that I have mentioned drew their descent, and from which, no doubt, many other lines were derived which we have not yet discovered in North America. Such are the lines of the elephants, the hyenas, the bears, the hogs, and the oxen. The ancestors of the strange, pouch-bearing marsupialia, have been found in part. These creatures, now confined (except the opossums) to Australia and the adjacent islands, were, at an early period, widely distributed over the earth. Some of these are found in the fossiliferous deposits of our plains and Rocky Mountains.

So soon as the possibility of learning the manner of creation of animals is admitted, curiosity and speculation are awakened. Many alternatives naturally occur to the mind. Were any of the living kinds of animals descended from any other living species, or have the ancestral animals all disappeared from the earth? Have the giants of ancient periods become reduced in size and strength, or have the giants of to-day grown from weak and insignificant beginnings? Have things grown more and more perfect with the lapse of the ages, or have they degenerated from more perfect ancestors? Have these changes advanced alike in all continents, or have they proceeded differently in different parts of the earth? Such are the questions that confronted the student of North American vertebrate paleontology fifteen years ago, and some of them could only be answered by North American material, not only because its record is the most complete, but because, as the second continent studied, it furnished the first opportunity in the history of the science for a comparison with the record already placed before us by the paleontologists of Europe.

Answering the last question first, it has been conclusively proved that there has been a general correspondence in the progress of vertebrate life in the two continents of the northern hemisphere. The differences, though numerous, are of minor importance. Some families of vertebrata have existed on the one continent, which were absent from the other, but the number of such is not large. Even the same genus occasionally existed on both continents.

The other questions must be answered by reference to the genealogies themselves, or phylogenies, as they are called.

In tracing back all the lines to which we have yet had access, the same kind of changes is found to have taken place in all of them. Let us take, for instance, the animals with hoofs. These embrace the cloven-footed and odd-toed orders, with their many species and families, which are represented by the ox, deer, camel, hog, and hippopotamus, for the cloven-footed ; and the horse, tapir, and rhinoceros, for the odd-toed. Most of these creatures walk on their toes. Many of the first-named group have but two toes, more or less united together, while the horses, of the second group, have but one toe. The bones of the two rows which form both the palm and the sole alternate with each other ; and the ankle-joint is a well-constructed tongue-and-groove arrangement. The teeth in many of them are highly complicated by the infolding of the enamel of the crowns of the molars, and this special development of the molars has been accompanied by a corresponding reduction in their number, and in the number of the incisors. In tracing the lines of these animals backward in time we have made the following discoveries : First, the infoldings of the enamel of the molars become shallower, and are finally represented by the valleys between four hills or tubercles, which stand to each other so as to be inclosed by a square figure. The number of the molar teeth increases. If incisor teeth were absent, they appear. The toes increase in number, becoming five on all the feet. The step becomes plantigrade or flat-footed, the heel reaching the ground. The tongue and groove disappear from the ankle-joint, which becomes flat. The bones of the two rows of the carpus and tarsus no longer alternate with each other, but rest, each one of the first on each one of the second row only. In 1874 I foretold that the ancestor of all the mammals above mentioned would prove to be a "pentadactyle, plantigrade bunodont"; that is, a five-toed sole-walker, with tubercular molar teeth. In 1881, seven years later, I obtained evidence that such a type of mammals abounded in North America during the early Eocene Tertiary period, and the prophecy was fulfilled. The best-known genus of this division has been called Phenacodus, and the figures of it will be found in the "American Naturalist" for 1884. In a still earlier formation of the Eocene, nearly all the hoofed mammalia were found to be of this type, showing conclusively that this group, which is known as the Condylarthra, was the ancestor of all hoofed mammals (Fig. 1).

FIG. 1.—SKELETON OF THE PHENACODUS PRIMÆVUS. (Cope.) One of the Condylarthra, one seventh natural size. Found in the Eocene bed of Wyoming Territory. (From the "American Naturalist," September, 1884.)

But the Condylarthra were also ancestors of a still more important line of mammals. A remarkable type of quadrupeds known as lemurs at present inhabits Madagascar and some parts of Africa and Malaysia. These creatures, known by the Germans as *Halbaffen*, or half-apes, present a curious combination of the characters of monkeys and carnivora of the raccoon pattern. They could easily have stood in the position of parents to the monkeys in general; and suspicions to this effect have been abundantly confirmed by the discovery of numerous representatives of the sub-order *Lemuroidea* in the Eocene beds of both Europe and North America. And these again have been traced as certainly to the Condylarthra as ancestors, so that this group is again proved to be the ancestor of man as well as of the hoofed animals. And here was fulfilled another prophecy made by the writer, along with the one already mentioned, viz., that the ancestor of man also, would be found to be a "pentadactyle plantigrade bunodont."

An especial point of interest in the phylogeny of man has been brought to light in our North American beds. There are some things in the structure of man and his nearest relatives, the chimpanzee, orang, etc., that lead us to suspect that they have not descended directly from true monkeys, but that they have rather come from some extinct type of lemurs. Lemurs, which fulfill this anticipation, have been found in our Eocene beds, and belong to a peculiar genus which bears the name of Anaptomorphus. These creatures have a dentition more like that of the anthropoid apes than any living lemur

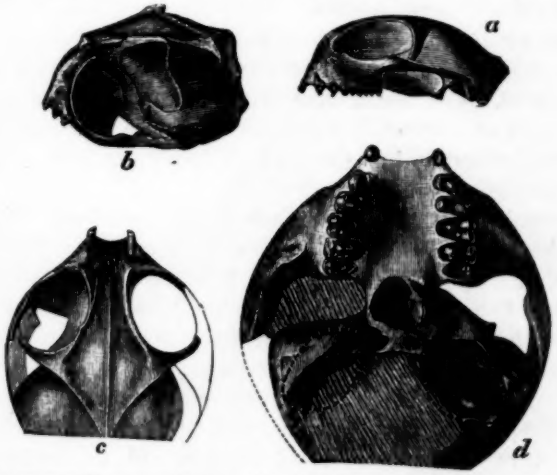


FIG. 2.—SKULL OF THE PRIMITIVE LEMUR (*Anaptomorphus homunculus*) (Cope). Natural size, except Fig. *d*, which is four thirds natural size. (From the Eocene of Wyoming.)

exhibits. They had the most acute senses of sight and hearing, if we may judge from the bony parts which surrounded those organs. They also had larger brains than those of any other mammal of their period, though they did not differ much in this respect from the existing

lemurs. Both of the two species known are small, not probably exceeding a gray squirrel in size. Only the skulls and jaws are known (Fig. 2).

But the Condylarthra prove to be the ancestors of a still greater population of descendants. We have traced all forms of grinding teeth up to a pattern which consists of four tubercles or cones arranged within a square. But it has been possible to show that one of the four tubercles appeared after the other three, as an addition to them, so that the earliest form of molar or grinding tooth was tritubercular, and that the quadritubercular was an outgrowth from it. Now, one of the three families of the Condylarthra has tritubercular molars, and there is little doubt that it was the ancestor of the two other families. The principal genus of this family is called Periptychus. From this family came an order of hoofed mammals, which never rose to the possession of four tubercular grinders, although the crowns became crested by the modification of the three which they possess. This order, the Amblypoda, had a short life in geological time, and did not grow in the dimensions of the brain, but developed huge skeletons with skulls that sprouted into horns and strange processes.

The Condylarthra with three tubercles are probably also the ancestors of the carnivorous orders. The lions, tigers, wolves, and bears of to-day can be shown to be descendants of animals absolutely intermediate between themselves and the animals just mentioned. These half-carnivores, or Creodonta, have, like the ancient hoofed mammals, more numerous teeth than their modern representatives, and differ from the true carnivora in just the ways, in limbs and feet, that we have seen that the ancient hoofed mammals differ from their modern descendants. Creodonta were not such dangerous animals as the carnivora, with some possible exceptions, because, although they were as large, they generally had shorter legs, less acute claws, and smaller and more simple brains.

This genealogy, it will be seen, does not show us the ancestors of the Condylarthra. This remains for future discovery. It is, however, probable that they will be found in the earlier geological periods, among some of the marsupial mammals only known thus far from the jaws and teeth. It must also be noted that a number of these ancestral groups are represented in the existing fauna by a few genera. Of the Condylarthra, a near relative exists in the Hyrax, or cony, which now inhabits Africa and Western Asia. Of the Creodonta, several genera exist in Madagascar, West Africa, and the northern hemisphere. The mastodons are late representatives of an ancient type, and their phylogeny has not yet been fully made out. But they certainly also came from the Condylarthra.

There is a remarkable likeness between the history of the development of the reptiles and that of the higher mammals, in one respect, and that is, that they have apparently all been derived from a single

order, which occupied the earth at one (an early geological) period. As reptiles are inferior to mammals in the scale, so they are of earlier origin. The primitive reptilian order first appeared in force on the earth during the Permian epoch—that populous time which immediately followed the age of the true coal. If it existed during the coal-measures proper, it has not yet been found in them in North America. This order has been named the Theromorpha. Its representatives have been found in Russia, Germany, South Africa, Illinois, Texas, and France. I give the names in the historic order of discovery. It embraced both carnivorous and herbivorous forms, and species of sizes from that of the Malayan tapir downward. Those with piercing teeth occur everywhere, and those with grinding teeth in North America only. South Africa furnishes us with genera with leaf-shaped teeth, and others with no teeth at all. This order represents the first air-breathing land-population of vertebrates, and they evidently fulfilled most of the functions of the mammalia of to-day, though none of them were fliers, so far as known. Many of them had strange physiognomies, with blunt noses and large nostrils, and long teeth mingled with other smaller ones. Besides having given origin to most of the reptilia, this order presents many points of resemblance to the mammalia. Some of the bones resemble very closely those of the duck-bill or Platypus of Australia, and some of the bones of the skull are more mammalian than the corresponding parts of any other reptiles. It is probable that the lowest order of mammalia, which is to-day represented by the duck-bill (the Monotremata), were derived from the Theromorpha. (See "Proceedings" of the American Association for the Advancement of Science for 1884.)

The different lines of reptiles have been traced less completely than those of the mammalia, partly because their history is more ancient, and the formations where their remains are preserved have suffered greater disasters. The changes that have appeared with advancing time have been in the bones of the shoulder-girdle and pelvis, in the limbs, vertebræ, and skull. Certain changes in these parts resulted in the appearance, in the period immediately following the Permian (the Triassic), of the orders of the sea-saurians, the flying saurians, and the land-saurians or Dinosauria. In the next period, the Jurassic, we have the first certain knowledge of the tortoises and lizards; while, in the following ages of the Cretaceous, we get the pythonomorphs and the snakes. All of the existing orders were in the world by the beginning of Tertiary time, but the great monsters that characterized the middle period of the earth's history were only represented by the crocodile branch of the Dinosauria.

The changes of structure which these several lines underwent in the course of the ages were quite different from those which the history of the mammalia exhibits. Instead of becoming more perfect organs of locomotion, the limbs, if we except those of the flying rep-

tiles, lost some of their special characters, becoming more remote from the mammalian type. The pelvis became weaker and more open. The shoulder-girdle lost parts in some orders, and gained some expansion in others. The vertebræ became more perfectly articulated by the bodies, and in the case of the snakes by the arches also. Finally, the ribs lost one of their points of articulation with the vertebræ, and the jaws became looser and more open, and especially adapted to swallowing large bodies whole. The history consists of a successive departure from the mammalian type, and a running into a specialization, which, in some cases, means degeneration.

A curious specialization which supervened on the reptilan type is that of the birds. Various saurians exhibit unmistakable approximations to the birds. The land-saurians include types that walked on the hind legs and had many bird-like characters of the hinder feet and of the pelvis. The flying saurians present affinities in the same direction. The class of birds presents many perfections both general and special. Their brains are larger than those of reptiles, and they acquired warm blood. In their own specialty of flight they display wonderful power, while the highest orders add that vocal skill which makes them so pleasing to man. Here is a good example of advance in evolution. Cases of degenerate evolution are to be found in birds, but they are few.

The next lowest class, that of the Batrachians, prevailed during the coal-measure period. They expanded enormously during the Permian, and were worthy contemporaries in size and numbers of the theromorph reptiles. Their numbers diminished subsequently, as the record now stands, though some of the species maintained their bulk during the Triassic period. In modern times they are comparatively insignificant; frogs, toads, salamanders, sirens, and cœcilias not playing an important part in the existing fauna. In tracing the successive changes of structure of these creatures, one is forced to believe that degeneracy has played an important part. The bones of the skull have so diminished in number as to leave it in some cases in a condition comparable to that of the primitive fishes. In not a few modern types the metamorphosis is never completed, the animals remaining permanently breathers in the water. Whatever we may call such changes, they are plainly a specialization which has carried them further and further away from their starting-point; and, as in the case of the reptiles, this starting-point has been near to orders higher than itself. The Permian Batrachia are nearer in structure to the Permian reptiles (*Theromorpha*) than any subsequent form of Batrachia has been (Fig. 3).

Professor Agassiz pointed out that the early fishes presented relations to other vertebrata, as I have since shown to be true of the Batrachia and Reptilia. Some of the primitive fishes he called "sauroid" or "reptilian" fishes. Batrachian fishes would have been a more accu-

rate designation, for it is highly probable that it was from one of the early orders of fishes that the Batrachia took their rise. Omitting from consideration the lowest vertebrata, the sand-lances and lampreys, which are not fishes, we have remaining a body of animals which pre-

Fig. 3.—Skull of Eryops megacephalus. (Cope.) A Batrachian of the Permian period. One fifth natural size, upper side. (From Texas.)

sent great varieties of structure. Of the four great sub-classes into which they naturally fall, but one can be called true fishes. The others embrace the sharks, the chimæras, and the lepidosirens. It is interesting to note that these four divisions are more closely approximated during the Permian period than at any later time. An order technically referred to the sharks, and known as the Ichthyotomi, combines many of the characters found separately in three of the subclasses. The creatures which especially deserve the name of batrachian fishes, the ceratodonts, etc., also abounded during the Permian period. From this time the true fishes began to run their course. They have peopled all waters, and have branched into a greater diversity of form

than any of the other divisions of vertebrata. And paleontology and zoölogy show that they have pursued a course which is in its essential principle the same as that displayed by the Batrachia, and in a less degree by the Reptilia. They have diverged further and further away from the batrachians, which they once resembled, and in so doing have left behind them the general ascending line that led some of the land animals to become Mammalia. They have become specialized into types which have special modes of life adapted to special localities. Some of the lines of descent are clearly degenerate, as indicated by a loss of parts. Some of these degenerate lines inhabit the deep sea; others have become movably sessile, attaching themselves to fixed bodies. Others have found protection in an external armor of bony plates rather than in activity and sensibility. But many fishes are in their especial way wonderful exemplars of animal energy, though none of them rise high in the scale of intelligence.

In review of the results obtained from the recent study of vertebrate paleontology, certain principles may be clearly discerned. These are as follows: 1. The earlier types were more generalized, the later ones more specialized. 2. The specialization is sometimes upward or progressive, and sometimes downward or retrogressive. 3. The retrogressive development has been more general in early geological periods, the progressive more general in the later geological periods. For a more detailed exposition of these principles, see "American Naturalist" for February, March, and April, 1885.

It is not my intention in this article to do more than to display the facts of the case. The exposition of the hypotheses of evolution which explain these facts must be reserved for another article. Suffice it to say here, that the study of the changes of structure displayed by the lines of evolution, has brought to light some very definite exhibitions of the application of energy. The illustration of the *modus operandi* of this creative energy is a very important chapter of evolution, and one that interests mankind practically, even more than as food for his intellectual activity.

AN EXPERIMENT IN PRIMARY EDUCATION.

By Dr. MARY PUTNAM-JACOBI.

II.

ONLY one attempt was made during this year to teach the child the meaning of words. It was done through a simple generalization which had become indispensable in the study of geometry, when she passed from plane to solid figures. By means of wooden models she learned, in addition to the cube—the sphere, ovoid, oblate, cylinder, prism, tetrahedron, octahedron, and dodecahedron. She then was led

to make parallel lines of plane and solid figures with a corresponding number of sides or angles, then to abstract the Greek numerals *tri*, *tetra*, *penta*, *hexa*, etc., found to belong to both columns, and set this in the center, with the syllable *gon* on one side, and *hedron* on the other. An hour was required to complete the setting out of these figures, and arranging these titles with movable letters, which for the first time the child learned to use for spelling. The exercise was, of course, repeated again and again, until every step was perfectly familiar. From the beginning the child had no difficulty in connecting the plane and solid figures, nor in learning the numerals appropriate to each. The new effort at abstraction and classification was at first somewhat hard, but soon became easy. The facility with which the impression of forms may be made upon a child's mind, when this is as yet uncrowded by notions on the other qualities of objects, was shown by a little incident at this period. A few weeks after having made her first acquaintance with the oblate, she saw at dinner for the first time some small stewed onions. "Oh!" she exclaimed, "they have brought us some oblates for dinner." Another day, when she accidentally pulled the cord of a window-shade in a certain position she observed that she had thus made "two scalene triangles." Looking at the ceiling above a lamp, she called to me to notice how the light made three "beautiful concentric circles."

One other study during the year was made upon the intrinsic meaning of words. In the course of some observations on plants the child had learned to recognize the ovary and ovule, and to herself dissect them out of a flower. When this had been done, the analogy between the vegetable ovule and chicken-egg or ovum was easily pointed out, and the relation of the latter to the geometric ovoid. The four objects were then placed in a row on the table, the names of each spelled with movable letters, and then the common root *ov* described and taken out. The important and fundamental idea was thus grasped that there was an intrinsic meaning to at least some words, and also that objects associated by a common name, whose specific variations were of subordinate importance, must be classed together as deeply related, notwithstanding superficial difference of aspect. But this idea, once distinctly enunciated and understood, was then set aside for a season. That the idea was understood, I tested in the following way: At table the child remarked that a particular potato was "shaped like an egg." "What shall we then call it?" I asked. "An ovoid," was the reply. "Very good. Do you know what I thought you might call it?" "An ovum," she answered, with an air of mischievous triumph. "And why did you not?" "Because it is not an egg, but only shaped like an egg." I tempted the child with the suggestion that she should tease the waiter by asking him to bring us some ovules instead of eggs; but the instinctive modesty of childhood recoiled from the pedantic proposition.

The necessity for precision in the use of terms, thus initiation into scientific terminology, was enforced incidentally on another occasion. A playfellow much older than the child picked up a piece of mica and called it isinglass. This conventional inaccuracy I strongly rebuked, and, procuring a piece of real isinglass, led the child to note its difference, and to condemn in private and without malice the slovenly language of her presumably untaught comrade. Now, the child had a doll called Rosa, and was in the habit of illustrating any absurdity by pretending that Rosa was guilty of it. Some time after the conversation on the isinglass she was watching a stream of water falling in the sunlight from a hose. She exclaimed: "See the beautiful silver water coming from the old gray hose. Rosa would have called that mica!"

When the box of wooden geometric models was thoroughly mastered, after about six months' study, I procured for the child a set of models of crystals, such as are used for studying mineralogy. About half of these proved too complex for study, but the child easily learned to recognize and distinguish twenty-six, partly simple, partly compound forms. As each face of the crystal showed some plane figure which she had already learned, and as she was also familiar with the Greek numerals from three to twelve, it was generally easy for the child to devise the name of the crystal, even when apparently so repelling as a scalenhedron, rhombic dodecahedron, right rhombic pyramid, etc. It was interesting to notice her capacity to discern the general outline of a crystal and thus its generic features, and afterward to distinguish the secondary divisions of its sides, or the specific characters; thus in a four-faced cube, a three- or six-faced tetrahedron, a three-faced octahedron, etc. The forms in the four systems of crystallization were learned by repeated handling of the models, until the child's perceptions had become saturated with them, and she could, for instance, discover for herself four-faced cubes in the curved molding on staircases. Then, at the beginning of the second year, the crystals began to be copied in clay, and opportunity then afforded for studying their axes, or the basis of their classification, by means of long pins thrust through the soft model in appropriate direction.

Arithmetic, the second science in Dr. Hill's category, was begun several months after the first studies of form and outline. Instead of the beans so frequently recommended, the child used sticks of different sizes and colors. For two or three months she studied such numbers as seem almost to form natural complex entities, and hence have often been sacred numbers, thus: four, nine, ten, twelve, twenty-four, thirty-six. The child was exercised in dividing these up into symmetrical groups, whose resemblances she was trained to tell at a glance by the eye, before enumeration. Thus she learned to form groups of threes, fours, and sixes, and to unite them in as many fantastic combinations as could be invented. The object was to effect the transition from the perception of form to the conception of number by a series

of visual impressions as vivid as possible. The breaking up of a whole into parts really precedes in facility the additioning of parts into a whole, for the reason that the power of destruction in a child obviously precedes the power of construction. Froebel's fifth gift of cubical blocks has its first application on this fact, since the entire mass forming a cube may be broken up into twenty-seven smaller cubes. When we reached the number twenty-seven, I told the child it was the smallest cube that existed. But she having a year previously, when only four years old, learned to handle these same cubes, corrected my error, and demonstrated triumphantly that eight blocks would make a still smaller cube. The incident shows the tenacity of ideas once implanted in the right way and at the right time.

It is much more difficult to teach a child to subtract than to add, a fact upon which Warren Colburn sagaciously comments. In the discussion of practical problems, a hitch often occurs in the child's mind which may be quite unsuspected by the teacher. Thus, if Henry and Arthur go to buy a ball which costs sixteen cents, and one boy had six cents and the other seven, I found the child unable to solve the problem as to how many more cents were needed, because, as she said, she could not take thirteen from sixteen, since the very trouble was that the boys did not have sixteen cents. It was necessary to use sticks, and with the distinct formal agreement that those of one color should be known to represent an imaginary number, those of another color the number of actual things manipulated. But what a stride for a young child's mind to make, into a sphere neither real nor imaginary, but where the existent and the non-existent are indissolubly associated in an ordinary practical affair of every-day life!

From the beginning the decimal system imposed itself spontaneously upon the child's mind, on account of the facility of visibly recognizing groups of five and ten sticks, and of verbally recognizing their successive additions. In this way the multiplication-table—the famous despair of little Marjorie Fleming—was mastered with great ease by this far less gifted child. Every one remembers the fierce vehemence of Pet Marjorie's protest, "But 7 times 9 is devilish, and what Nature itself can't endure!" It is so, if presented as an isolated fact. The child I taught, however, discovered of herself that the successive addition of tens was as easy as that of ones. After that, when she came to add (or multiply by) nines, she would say, first add ten, then say, and nine was one less. If it were eight, it was two less, etc. After a fortnight of these exercises, she was asked one day out of study-hours what was the sum of 14 and 19, and answered immediately 33. Upon being asked to explain the process, she said, "10 and 19 makes 29, then I must add 4 more, and 1 and 29 are 30, and 3 more are 33." When three decimals were reached, a somewhat laborious exercise was performed. Thus, to operate with 138, the number 100 was constructed out of ten packages of purple sticks, each package

containing ten sticks. These packages were placed in a row; underneath was a second row, containing, to represent the number 30, three packages of yellow sticks, each containing ten; finally, a third row of eight units was made with green sticks in a single series. In this exercise the sticks were all of the same size; in another, later, a hundred was represented by a single long stick, usually purple, a ten by a yellow stick next in size, a unit by a stick still smaller and green. Thus the original and clumsier representation was condensed by the substitution of an expressive sign for the literal numbers, and as soon as the sticks became used as signs, and not as the objects really to be counted, the mutual relation of their respective sizes also ceased to be literally exact, and became merely schematic. Thus was gradually managed a transition to the use of pure written signs or symbols. The transition initiated and enlarged the condensation of Roman into Arabic numerals. Knowledge of the process of subtraction, especially in three and more decimals, was essentially facilitated by this device with sticks, and the terrible difficulty of borrowing ten quite overcome. Thus, if the number 288 were to be taken from 362, the larger number would be represented by three long purple sticks, six shorter yellow sticks, and two green sticks, the shortest of all. These colors were always selected because harmonizing so well with each other. Then, similarly, the 288 was represented by two purple, eight yellow, and eight green sticks. It was easily recognized by the child, that one of the yellow sticks could be removed from the ten sections of the 362, and ten green sticks substituted, bringing the entire number of units up to twelve, from which the eight of the lower figures could be taken. It was also obvious that, when one yellow stick had been taken away, only seven remained. There was no need, therefore, to employ the usual confusing statement that a ten must be borrowed from the upper figures, and later restored to a different place in the lower.

The study of abstract numbers, with Colburn's arithmetic, was begun when the child was five and a half years. At the end of a year she had thoroughly mastered the first four rules, including both "short" and "long" division, and was considerably advanced in the study of fractions, proper and improper.

The last study entered upon during this year was that of natural objects, and, for obvious reasons, plants were chosen for this purpose. I suppose that most persons seriously interested in education are acquainted with Miss Youmans's admirable little "First Lessons in Botany," and the plea she makes for this science as a typical means of training the observing powers of children. According to her plan, the first object studied is the leaf—and the pupil is taught at once, not only to draw the leaf, but to fill out a schedule of description of it. Much may be said in favor of this method, which proceeds from the simple to the complex form, but it is by no means the only possible

one; the writing part of the scheme is, moreover, impossible for a child who has not yet learned how to write. There is another method which consists in seizing at once upon the most striking aspect of the subject, and which shall make the most vivid impression upon the imagination. For this purpose the leaf is the least useful, the flower the most so. The earliest botanical classifications are based upon the corolla, and, in accordance with a principle already enunciated, a child may often best approach a science through the series of ideas that attended its genesis. The conditions are different for an adult, who requires to get the latest results; the child's mind is always remote from these, but often singularly near to the conceptions entertained by the first observers. Again, it is unnatural to enter upon the beautiful world of plants by the study of forms and outlines—which is much better pursued when abstracted from all other circumstances, as in models of pure mathematical figures. But with plants comes a new idea—that of life, of change, of evolution. It is fitting that this tremendous idea make a profound impression on the child's mind; and this impression may be best secured by watching the continuous growth of a plant from the seed. The study of life is a study of events, of dynamics, of catastrophes. The earliest observation perceives the extraordinary influence of the surrounding medium upon the destinies of the living organism. It is not difficult to surround these destinies with such a halo of imagination as shall impress on the mind a sense of the mystery, sanctity—I may add, the necessary calamities of life—before it has become absorbed in the consideration of living personalities.

I trust it will not seem a piece of bathos when I add that I initiated the pursuit of these objects by making the child watch the growth of seven beans on a saucer of cotton-wool. A specimen bean was first dissected, and its principal parts named—the cotyledons, the embryo with its radicle and plumula, the episperm. The daily reference to these terms speedily rendered the child quite familiar with them. To seven other beans were given appropriate names, as of a band of brothers, and they were then planted on cotton-wool by the child. A daily journal of events was opened, in which I wrote each day or two, at the child's dictation. As she had learned the Arabic numerals, she inserted these herself in the protocol whenever necessary. The entire history of each bean was thus written out, and the successive steps of its development, from the thrilling moment when the radicle first peeped out, to the time when, after transplantation to a flower-pot, the plumula had developed to a long, trailing vine. The rate of growth of this vine was measured day by day exactly, with a rule, the number of leaves counted, etc. But the mathematical considerations were here subordinated to a larger idea, that of the succession of events. Some of the beans molded early in their career, and the relations of this catastrophe to the accidental differences of position, moisture, etc., were carefully studied. On one occasion the child dictated to me the follow-

ing entry for the journal: "The episperm, on the under surface of Tertius, is all black, and has split, leaving a space the shape of an equilateral triangle, with the apex pointing to the convex edge of the cotyledons." In the summer, when flowers could be obtained from the woods in abundance, the child made collections of ovaries and ovules, and was never tired of finding the latter asleep in their beds, in so many differently shaped houses. At this time the static considerations were allowed to predominate, and the child rather forgot the function of the embryo seeds—so much so that, upon seeing some small pieces of ice lying in half a musk-melon, she said that these were like the ovules in an ovary. At the beginning of the second year, the study of plant-growth was resumed with seven hyacinths, that received appropriate names, as seven sisters. The first lessons in written expression coincided with the beginning of this new study; for now the child was allowed to write the plant-journal herself. The exercise was complex. The child first examined the hyacinths, and noted whether anything had transpired since the last observation. She then framed a spoken sentence, in which such an event was accurately described. She then dictated the writing of this sentence as a whole, which she was afterward to copy. During this dictation, some knowledge of spelling was incidentally acquired; for the child was led to spell by sound, and without reference to silent letters. The words she had not yet seen. Finally, when fairly at work at the writing, the meaning of the sentence was temporarily ignored, and attention closely concentrated upon the forms of the letters, and no mercy shown to inaccurate imitation of them. Thus, one day she entered the observation that Blanche, in a blue glass, had grown much more vigorously than Aura, in a dark one; and a blue glass was given to the less favored sister, in the hope that she would improve. She noted that the tips of the white roots were gray and conoid in shape (making the observation herself independently), and was allowed to demonstrate the function of these tips by cutting one off and seeing the growth of that root arrested. On another day she first discovered, then described, then wrote down, that the first broad leaves of Blanche had split open, showing two others at right angles to them. This was her first perception of this remarkable law of phyllotaxy, and she herself illustrated it by making two loops with the thumb and finger of each hand, and making them intersect each other. The previous acquisition of mathematical conceptions was constantly shown to facilitate and render precise her observations of complex objects.

It was rather as a concession to a prevailing prejudice that at this time the child was taught to read. This study, usually made of the most importance, was held for this child to be quite subordinate and easy, and little stress laid upon it. The child was allowed to follow her own inclination, to divine the subject of the chapter from the picture at the head of it, and, to a considerable extent, the words in each

sentence from the context; when the wrong word was thus suggested, she was obliged to spell out the real word by sounds, always seeking first the central or predominant sound, and building up the word around it, instead of enumerating the letters in order. Thus in the word *scratch* she took out the letters *a t*, as the central nucleus, preceding the first by the sound of *r*, then of *c*, then of *s*; then, when the sound *scrat* was complete, adding that of *ch*. She was made to read as much and as rapidly as possible, relying upon constant repetition and association of ideas to secure familiarity. Thus unconsciously the conception was continued, that written as well as spoken language was an outgrowth of thought before the attempt was made to study it as an object of thought. This method is like that of learning to walk before studying the laws of Weber on locomotion.

This method may seem slovenly, but, after all, it is both the natural and scientific method of studying an unknown tongue, which must be deciphered by the context. How else did Champollion read the Rosetta stone, or Eliot find a written language for his Indian Bible? Throughout this period the task of reading was treated as something so easy as to be insignificant, and was so regarded by the child herself.* The main intellectual work of the day's lessons (whose duration was never more than an hour and a half) was concentrated upon the arithmetic, map-drawing, analysis of flowers, and the geometrical studies, that she now pursued by the help of Hill's "First Lessons," and Spencer's "Inventional Geometry." She studied angles, vertical and adjacent, the relations of angles and circles, and the measurement of the former by the latter. Exercises in these were practiced daily with compass and ruler; and, when lines drawn with the pencil failed to give a large enough visual impression, they were designed with colored sticks. This enlargement of the material illustration never failed to clear up any obscurities. At the time these notes cease, the child was six and a half years old.

I have tried to make clear in these few notes the outlines of a (single) experiment, which seems to me to show that the mental education of even a very young child may be imbued with scientific methods and even ideas which should furnish suitable preparation for advanced scientific studies. It can not be a matter of indifference that such habits of mind are acquired from the beginning, or only after much previous faulty training. What comes first will always remain the most important, will always dominate the rest. Experience in the medical education of women has repeatedly brought home to me the difficulty of teaching such an art as medicine to persons who come to it through the prevailing systems of school discipline, especially those which are applied to girls. Experience with one little girl at least convinces me that the aptitude for vivid and accurate perception, and for

* What is easy, when taken instinctively, may be incredibly difficult when itself becomes the object of thought and study.

scientific method in ideas, often exists where unsuspected, and only demanding proper cultivation.

As an illustration of the method described in the text, when carried into more complete studies, I insert an exercise written by the child when six and a quarter years old. It is a description of a wild Iris, which she analyzed herself on successive days, writing down the results from *memory* on the next day. She was never told anything, but obliged to discover for herself each fact, to compose the sentence describing it, and to spell by ear the words of the sentence without copy. She was allowed to insert in her description whatever fancies occurred to her. The headings and order of evolution of the subject were alone dictated. With nearly all the technical terms she was, however, already familiar; two only were told—"perianth," as opposed to corolla, and "blade." Before analyzing the Iris she was obliged to take a long walk to the woods for it, and first to draw a map showing the way, and by means of the compass. Two intersecting lines from sight-objects were dictated by me, and the fact learned by this and another previous experiment which had failed, that to locate an object in space at least two lines are required. The final description, whose writing occupied two or three weeks, was as follows:

The Rainbow Family.—(This name was given as a literal translation of *Iridaceæ*, and as a return in a spiral to the first natural object studied eighteen months before, the rainbow. The way was also prepared for the future historical study of the myth of Iris.)

Iris Tricolor.—(The numeral was already familiar.)

Perianth = 6 Petals. (The algebraic signs and numbers were used to indicate that in a scientific document, not a flowing style, but the fewest words and most concise expressions were required.)

These stand on top of a long tube in which the style is locked in. There are two kinds of petals: 1. Three which are the biggest, and have three colors. There are two parts to each—the upper broad part called the blade, and the lower long narrow part. (The term "blade" was here taught for the first time.) The blade is first purple; in the middle is a gold stripe which runs into the narrow part. (At this point, the child drew and painted from memory, on the margin of her protocol, a picture of the petal.) Between the purple and gold the blade is white. These petals curve outward and downward, so that the gold stripe comes on top. The bees see it and come for the pollen. (First introduction of a Darwinian law.) 2. Three petals, which are entirely purple, are vertical, smaller, and stand between the others. (The child made another drawing by opening the flower on the page and tracing its outlines.) It is as if six girls were standing in a circle (here was introduced a botanical outline of the whorl, instinctively devised by the child, the circle being drawn accurately with compasses). Every other one leans back and stretches her arms out horizontally, as if to show her gold bracelet. The three others lean forward, and hold their arms up above their heads. (Prolonged contemplation of this lovely group tended to evoke such instinctive æsthetic conceptions as are at the basis of many pieces of statuary, notably Thorwaldsen's Graces.) The gold stripe is like the orange feathers on the head of the bee-martin. The bees think it is a flower, and come and settle on the bird's head; then he catches them. (This illustration was suggested by the child, shortly after having seen such a bird which had been shot. She thus learned to step from one section of natural history to another, and also to seek analogies of organs in their functions.) Mamma says (here knowledge by testimony is distinguished from that obtained

by personal observation, which has not yet reached so far) that all flowers that want the bees to visit them have bright colors. This is like ladies who want the gentlemen to visit them, and then put on their finest clothes.

The Great Mistake.—We thought there were three more petals in the middle of the corolla. These were smaller than the others, and divided at the top like a funny M. (The child then made a drawing in illustration.) Each stands inside a gold-striped petal, and has a groove on the outer side like a bath-tub. In this a princess is bathing. She is a stamen, with a long, whitish anther like a veil over her head. So there were three stamens inserted with the petals.

How we found out the Truth.—(This process is introduced with some solemnity, as befits its importance.) 1. We looked to see how the pollen got on the stigma. (Introduction to the biological method of studying structure in association with function.) 2. We noticed that the pollen could slip down the groove into the tube leading to the ovary. 3. We saw that the petal-like pieces were fastened together in the middle of the perianth, making a solid white cylinder which passed into the green tube. (Another drawing from memory illustrated this.) 4. It was plain that the white cylinder was the style, because it went to the ovary. 5. Then mamma said (recognition of authority and testimony again) that the petal-like pieces were the stigma, immensely big. (The incident showed the function of the reason in unraveling the deceptions imposed by the senses and the superficial aspect of things.)

Ovary—at the bottom of the tube (ovary inferior)—has three lodges and a great many ovules.

(Thus the botanical analysis was rigidly accurate and complete. But, instead of being a dry schedule, it comprised a mass of vivid, glowing impressions destined to remain forever as a typical group of ideas in the child's mind. The prolonged, patient, sympathetic study of the individual preceded the abstract study of a class of flowers. In the future it was intended that the child should construct her own classes from among the botanical individuals she should really learn to know.)

THE FAUNA OF THE SEA-SHORE.

By Professor H. N. MOSELEY, F.R.S.

THE marine fauna of the globe may be divided into the littoral, the deep-sea, and the pelagic faunas. Of the three regions inhabited by these faunas, the littoral is the one in which the conditions are most favorable for the development of new forms through the working of the principle of natural selection. As Professor Lovèn writes, "The littoral region comprises the favored zones of the sea where light and shade, a genial temperature, currents changeable in power and direction, a rich vegetation spread over extensive areas, abundance of food, of prey to allure, of enemies to withstand or evade, represent an infinitude of agents competent to call into play the tendencies to vary which are embodied in each species, and always ready by modifying its parts to respond to the influences of external conditions." It is consequently in this littoral zone, where the water is more than elsewhere favorable

for respiration, and where constant variation of conditions is produced by the tides, that all the main groups of the animal kingdom first came into existence; and here also, probably, where the first attached and branching plants were developed, thus establishing a supply of food for the colonization of the region by animals.

The animals inhabiting the littoral zone are most variously modified, to enable them to withstand the peculiar physical conditions which they encounter there. Hence the origin of all hard shells and skeletons of marine invertebrata, various adaptations for boring in sand, the adoption of the stationary fixed condition, and similar arrangements. Almost all the shore forms of animals, however inert in the adult condition, pass through, in embryological development, free-swimming larval stages which are closely alike in form for very widely different groups of animals. Thus the oyster and most other mollusca of all varieties and shapes when adult, develop from a free-swimming pelagic trochosphere larva, and so do many annelids. Such larvæ can not be of subsequent origin to the adults of which they are phases. If such were the case, they would not have become so closely alike in structure. In reality they represent the common ancestors from which all the forms in which they occur were derived, and, as all these larvæ are pelagic in habits and structure, it follows that the inhabitants of the shores were derived from pelagic ancestors. The earliest plants were also probably free-swimming.

In the case of the cirripedia there can be no doubt, from the history of their development, that they were originally pelagic, and have become specially modified for coast-life; and in the case of the echinoderms the only possible explanation of the remarkable similarity of the larval forms of the various groups of widely differing adults is that these pelagic larvæ represent a common ancestor of the group. The madreporarian corals all spring from a pelagic larva. The colonial forms probably owe their origin and that of their skeletons to the advantage gained by them in the formation of reefs, and the increase in facilities of respiration consequent on the production of surf. In the deep sea they are very scarce.

The vertebrata are sprung from a very simple free-swimming ancestor, as shown by the ciliated gastrula stage of Amphioxus. The ascidians afford another evident instance of the extreme modification of pelagic forms for littoral existence.

The peculiar mode of respiration of vertebrata by means of gill-slits occurs in no other animal group except in Balanoglossus, which will probably shortly be included among vertebrata. Possibly gill-slits as a respiratory apparatus first arose in a littoral form, such as Balanoglossus, and hence their presence at the anterior end of the body, that nearest to the surface in an animal buried in sand. The connection of Balanoglossus with the echinoderms through Tornaria is very remarkable. Possibly Amphioxus once had a Tornaria stage,

and has lost it just as one species of Balanoglossus has lost it, as Mr. Bateson has lately discovered.

The littoral zone has given off colonists to the other three faunal regions. The entire terrestrial fauna has sprung from colonists contributed by the littoral zone. Every terrestrial vertebrate bears in its early stages the gill-slits of its aquatic ancestor. All organs of aërial respiration are mere modifications of apparatus previously connected with aquatic respiration, excepting, perhaps, in the case of Tracheata, tracheæ being most likely modifications of skin-glands, as appears probable from their condition in Peripatus. The oldest known air-breathing animals are insects and scorpions, which have lately been found in Silurian strata. Professor Ray Lankester believes the lungs of scorpions to be homogeneous with the gill-plates of Limulus. Birds were possibly originally developed in connection with the sea-shore, and were fish-eaters like the tooth-bearing Hesperornis.

The fauna of the coast has not only given rise to the terrestrial and fresh-water fauna; it has from time to time given additions to the pelagic fauna in return for having thence derived its own starting-points. It has also received some of these pelagic forms back again, to assume a fresh littoral existence.

The deep-sea fauna has probably been formed almost entirely from the littoral, not in the remotest antiquity, but only after food derived from the *débris* of the littoral and terrestrial faunas and floras became abundant.

It is because all terrestrial and deep-sea animal forms have passed through a littoral phase of existence, and that the littoral animals retain far better than those of any other faunal region the recapitulative larval phases by means of which alone the true histories of their origins can be recovered, that marine zoölogical laboratories on the coast have made so many brilliant discoveries in zoölogy during late years.

SIBERIA AND THE EXILES.

By Dr. ALFRED E. BREHM.

WHOEVER associates with the name of Siberia the idea of a vast prison is involved in as great an error as the person who conceives the country as an icy desert or an interminable *tundra*. The *tundras*, whose icy fields form a prominent feature in the polar regions, with the stunted vegetation of their southern parts, are no myths, nor is it a fiction that the Russian Government, following the example of France and England, has adopted a system of penal colonies, and has planted them in Siberia. But by far the larger part of this immense territory has been spared the presence of convicts; and the districts

in which the residence of persons of that class will justify the application of such a designation occupy a relatively small space in the country. It can not be denied that the transported persons, so far as they do not work in the mines, are subjected to a very strong restraint, but it is in no respect more severe than that which is imposed in the houses of correction of our highly civilized lands. Siberia is regarded by the mass of readers as a country full of discomfort and misery, and it is very hard to controvert that view. It is too much the fashion to consider the Russians as barbarians, and to accuse them of inhumanity. I feel compelled to enter a decided protest against so unjust a condemnation, and to assert as a fact that there are greater barbarians in Europe than the Russians. We shall have to apologize for the whole human race, before we can describe the Russians as the greatest barbarians. I myself formerly believed that one had only to scratch Russians to bring out their barbarism, but I have more recently had occasion to form my judgment from my own unprejudiced observations on the spot, and I consider it my duty, and the duty of every just and truthful man, to bear witness to the incontrovertible truth, and give an energetic protest against such systematic *a priori* depreciation of a people I have learned to respect. It is true that there are, in the great Russian Empire, as well as in other countries, men who might, should, and ought to be better, but we curiously see only the shady side of Russian conditions, and then perversely suppose that there is nothing good on the other side of the Muscovite lines. I can readily and with perfect conviction declare that, among the educated Russians of Russia, there are manifest a spirit of progress and a striving after better and higher things such as exist nowhere else, and that many of them afford rare examples of magnanimity and generosity. If we consider it from a purely geographical point of view, we shall find that Siberia is in no way, as a whole, a land of misery and terror. It is true that away up in the north are the immense ice-fields and the high moors, and the short, insignificant vegetation of the *tundra* does not offer an attractive picture; but there is also a larger Southern Siberia, where there is room for all kinds of enterprise, reward for every kind of work, and good living for every industrious man. Material suffering can not be spoken of in this part of the land; but in an intellectual sense there is much lacking without which we can hardly think of life. Thus, it seems to us something to be lamented that the people are four or five weeks behind the current events of the world. But if the question is one of making a living by means of hard work and a rugged constitution, and particularly of making a new start in life, then Siberia is to be preferred to nearly every other country. Yes, a new era has dawned over Siberia, and along the highways famous for "sighs, where night and day, with the frightful clang of chains, with lamentations, groans, and agony, the prisoners were driven on by the cruel knout," are now

wending free men, joyous with hope, with their families and goods, going to build up a more comfortable home than the old one in the rich fields of the Southeast. And all those who give themselves earnestly to it see their enterprise crowned with success. The false representations which are so widely spread respecting Siberia originate in the numerous maliciously colored descriptions of the country, and judgments of its condition, that flow from the pens of famous convicts. I can not exactly pronounce these reports unjust, but they should not be taken as wholly correct. It is a recognized fact that misery and wickedness pain the eye and the heart and provoke erroneous and unjust statements; particularly when, as is the case with the majority of the exiles in question, the conditions are complicated with politics. The situation of the ordinary exiles in the mines and of the settled convicts is relatively much better than that of the miners who are laboring under the despotism of capital in Germany. If one has no especial backsets in Siberia, if he can and will work, he will be able under all ordinary circumstances to earn a most comfortable living there. When I crossed the Ural the first time, I had only the ethnographic side of my journey in view, and thought little or nothing of the ethical side, which bore no relation to the object I was then seeking. I was not concerned with the exiles, nor in general could any man who stood in open conflict with the laws, not even a political dynamiter or murderer, have aroused any interest in me. But, from the moment when I found myself in the heart of Siberia and came in contact with its exiles, I felt it my duty to examine the ethical question more closely. I have gone down into the dens of vice, and made the acquaintance of the most common criminals—of thieves, robbers, and murderers; I have associated with political exiles; I have sought information everywhere; have made inquiries of officers and private persons, have visited prisons, collected statistics, taken down numerous biographies as given by the exiles from their own mouths, or as recorded by impartial persons; in short, I have become a regular philanthropist. I am aware of one thing, that I have taken all pains to discover the truth, and, if I have not been successful in it, the want of success must not be attributed to lack of good-will, but to the defects of my sources of information.

To make possible an impartial view of the condition of the exiles and prisoners in Siberia, we must first try to learn what the free-born Siberians may attain; and it is therefore incumbent on me to describe the general conditions before proceeding to the illustration and estimation of the situation of the convicts.

It is the region of the mines of the Altai, which, like most of Siberia, is an imperial crown-land, that should more especially be brought under view, for thither are sent those offenders whose sentences to death have been commuted; and the district plays an important part in the more or less romantically tinged accounts of affairs that are

sent out. The region, which comprises 8,200 geographical miles, is rich, immensely rich, in subterranean treasures. It is penetrated by veins of silver and gold. Up to the year 1861, seven hundred and thirty mines were opened, and two hundred and sixty abandoned. The precious metals are not the principal treasure; the region also contains copper, tin, antimony, lead, and iron, and includes an immense coal-field. The surface of the land is correspondingly productive, and will compare well in agricultural capacity with the best parts of Germany. The climate is generally mild. During four months a hot summer prevails, which is followed by two months of autumn, four of winter, and two of spring. The mean temperature is not high enough perfectly to ripen grapes, but oranges grow well in the southern parts. The fact that the people live to be very old is the best testimony to the good qualities of the climate. When I traveled over the country, in 1876, I was assured that only four doctors were settled within the whole of the vast territory, and they did not live in very great luxury. Men die here of old age without the help of medicine, and live long and happily without doctors.

Since the house of Romanoff has taken possession of the country, any one can settle there, cultivate such land as suits him, and erect factories, on the single condition of paying an annual rent of thirty copeks—about seventeen cents—per acre; but the fee of the land remains the Czar's; the tenant can cut the wood, but the soil belongs to the imperial domain. He can not mine for gold and silver, or other metals, for these go with the title to the land. As it always has been and is now generally in the Russian Empire, the old ways are encroached upon in every direction. The Romanoffs had for the exploitation of the mines mingled a number of their serfs from Russia with the men already there, and no one could enter upon a systematic or regular cultivation of the soil. The serf-laborers, with their wives and children, received as much as was necessary to satisfy their wants. Till 1861 the population consisted, with rare exceptions, of imperial officers and socage-laborers, mining experts, and superintendents, who were always trained men, and contributed much to the amelioration of the manners of their underlings, who, in other respects, had much to complain of in their treatment. On the 1st of March, 1861, there were living on the crown-lands 145,630 souls, or, in round numbers, 350,000 persons—for in Russia women and minors are not enumerated in the statistical reports. In the mines alone more than 25,000 men were employed, when Czar Alexander, with a stroke of the pen, abolished serfdom, not out of humanity, but in order to weaken the political power of the Staroste.

The serfs in the mines represented only about half of the 25,000 miners—or 12,000 men—and became free peasants without owning any property in the real sense of that word, all lands belonging to the Czar; but they received as much land as they needed, on the

usual terms of a ground-rent of thirty copecks per acre. The other half of the miners continued at their old employment, and are now efficient laborers, who accomplish more in freedom than they formerly did in servitude, so that the mines are becoming more profitable every year. Up to the year 1861 the return in most cases did not cover the outlay. In order to cover the deficiency of laboring forces, persons condemned to death and then pardoned were added to the free miners.

From this time agriculture improved rapidly, and in the year 1876 half of Siberia was already settled. A free peasantry was formed, such as we might desire to see in the whole of the country. There are no servile persons like the Russian peasants, and, when I occasionally by inadvertence called them "Russians," they would immediately inform me that I was mistaken, they were "Siberians." "There is no servitude here," they would add; "we are all free men. Heaven is high and the Czar rich, but we have nothing to fear, for we are in Siberia." Not the farmers alone, but the officers also, are inflated with this air of freedom, and not unfrequently may we hear from the mouth of one of the latter such words as, "If you want to see slaves, you must go back over the Ural into Russia, where their home is." And these people speak with truth, for, although serfdom is legally abolished in Russia, it continues to exist in fact, even among the mercantile classes.

I had already been told in Russia that prosperity was generally prevailing in Siberia, and shone in strong contrast with Russian poverty, and I am again obliged to say here that even Russian poverty is not so repulsively conspicuous as the misery in the German factory and mining districts. I do not go too far in asserting that the Siberians lead a happy life; and the best evidence in confirmation of this opinion is found in the fact that the idea of an independent Siberia, not attached to Russia, has already begun to dawn in a few speculative minds. I must guard myself against the suspicion that I am falling into a merely subjective judgment. My opinion is founded on careful observations and conscientious inquiries. It is generally known that in all countries and governments the farmers are always complaining of hard times and high taxes, and I therefore took special pains to compare these peculiar complaints with the representations of the officers. I had arranged a kind of informal catechism in my head, and used it on every suitable opportunity. The answers were, in all cases, if not literally, substantially alike, and I can not forbear repeating one set of them here. My conductor and myself were staying a short time in a little mountain-town, and in one of my excursions I overtook an old peasant who I afterward learned was the head-man of a small village. I invited him to take a seat in my carriage, and at once opened my catechism upon him:

"How is it with you here?" said I.

"God bears with our sins," he replied.

"Yes, he is very merciful, but how are affairs otherwise?"

"We are contented."

"How are the wife and daughters?"

"They are contented."

"And the other children?"

"They are all contented."

This peasant answered my first three questions with the words "We are contented." I was born among farmers, and believe that I know them well, as I have had much to do with them, but no German farmer ever told me he was contented.

I next turned from the family to the live-stock, and asked, "How many horses have you?

"Thirty or thirty-five."

"Don't you know exactly?"

"No, there may be some new colts, and some may have been stolen or eaten by wolves. I sometimes use six, sometimes eight, and sometimes fourteen."

"Then you have twenty more than you use. You will sell them?"

"That may be."

"But what will you do with so many extra beasts?"

"That's nothing to you."

I would remark that the last answer is a polite form of expression among Siberian farmers. I continued:

"And how many head of cattle have you?"

"That is my wife's affair."

"And how many hogs?"

"Nobody knows."

"How large crops do your fields return?"

"I am satisfied if I get ten times as much as I sow."

"Are your taxes heavy?"

"We are satisfied with them."

"Have you farmers nothing to complain of?"

"Oh, yes, we are getting crowded here; there are beginning to be too many people in the country. If I were not so old, I should move farther east."

"But," I replied, in surprise, "where are the villages? I don't see any."

My village-chief was silent, and shook his head doubtfully. The fact was, the nearest village was ten miles away. The man was satisfied with himself and his family, satisfied with his live-stock and his crops, and satisfied with his taxes, and over-population was apparently the only thing which he and his peers conceived needed to be set right. On this point we should remember that not nearly all the land is yet taken up, and that many of the farms are as large as, and sometimes larger than, the most extensive German manors. Even a spoiled American farmer would be satisfied with such an area. In the midst

of these extensive estates stands the spacious log-house, surrounded with barns and sheds, which, possibly, are not large enough. Hardly anything is large enough for the Siberian. I have made personal confirmation of this greed for extension and space in the towns, where it is often carried to excess ; thus I have seen parlors where the mirrors and sofas could be counted by the dozen. In bright contrast with the stereotyped complaints of the farmers concerning the too thick population is the fact that they are all proud of having a numerous progeny. The farmer loves his land, his cattle, his summer and fall, but he loves above everything a large family, while, notwithstanding his prejudice against strangers, he lives in the perfect conviction that the country needs men, and he governs his conduct accordingly. In every other country in the world there are foundling-hospitals ; in Russia they are numerous, but in Siberia there are none. If a mother is not able to take care of her child, she will offer it to the nearest farmer, and he will be as glad to have such an increase in his family as if it were a fine colt foaled to him. Till 1856, marriage of free persons was permitted at any age ; now the marriageable age is fixed by law at eighteen years. To show how little in earnest the people are in their deprecation of over-population, they as a rule marry immediately after they have passed the legal age, and their families increase, with mathematical regularity, by at least one member every year. It may sound strange if I mention the fact that, notwithstanding the low marriageable age fixed by law, elopements are common. It is true they are of a quite peculiar sort, and they might be divided into elopements with and elopements without the consent of the parents on either side. This custom so illustrates the character of the peasantry of all regions, that I must not dismiss it with too brief a mention. Elopement with consent is an important matter. The young pair are agreed, and have the full acquiescence of the parents on both sides. But every marriage calls for a wedding, and a farmer's wedding is, under ordinary circumstances, no child's play. The relatives and friends must be invited from distances extending to fifty or a hundred miles. The substantial part of the feast is rather a secondary affair to the farmer richly provided with farm products and cattle, but then drink must be furnished, and the national drink is dear, and will be consumed on such occasions in immense quantities. In order to escape the expense of this provision, which would be borne equally by both families, the parents of the bridegroom advise him to elope with his beloved, and her parents advise her to consent to the elopement. After receiving the blessings of the crafty parents, the young people steal away into the bush. On the next day the friends set up a cry as of murder, beat around for a while, and laugh in their sleeves. The young couple must of course come back after a little while and receive forgiveness, but there can be no wedding-feast after such a "scandal." The latter is confined to a narrow circle, and the brandy is saved. The second kind of elopement is

of a more serious nature, but in it also thrift and brandy play the chief parts, the latter that of a propitiator. The custom prevails for the bridegroom to pay to his future mother-in-law before she will give her acquiescence a definite sum of "bride-money," the amount of which is regulated according to the standing of the parties. The Siberian youth, having thus made things all right for his future, escapes with his beloved by night and under favor of darkness, and with the scandal of the abduction of the daughter a second matrimonial candidate is out of the question. The mother screams and curses the couple for a little while, but the storm soon ceases. The bridegroom knows the people he is dealing with, and, after the first spurt of vexation is over, returns with a stout brandy-flask, from which he pours out to the angry mother-in-law till she is propitiated. Then the ruined daughter appears, and a general forgiveness follows, with a family wedding-feast, in which immense quantities of brandy are consumed.

The young pair go right to housekeeping, and in the course of ten years the former abductor will be able to stretch himself before the door of his own unencumbered residence. In the reception-room will hang waving tapestries, and in the bedrooms will rustle silken curtains and canopies. I have seen hundreds of such cheerful family pictures and rejoiced over them. The people form a splendid race, and are happy. "I am a Siberian!" sounds from the mouth of one of them like a shout of exultation; "I have nothing more to desire."

A similar happy future awaits the convict-exile, if long life and success are given him, and he is endowed with courage and energy. "He is consigned to the mines, and will die there by inches with chains on his hands and feet," is the current expression when speaking or writing of a Siberian convict. But here, too, as in other cases, the colors are too darkly painted. I do not feel called upon to deplore the excessive harshness of Russian justice, or to indulge in general criticism, but it is true that not only criminals, but also disagreeable persons, vagrants, and political oppositionists, are sent to Siberia under cover of judicial proceedings. What is now imposed in Russia as a punishment was also administered not so very long ago in Germany and even in free Switzerland.

Whoever, by a judicial sentence, or by an administrative measure, is exiled to Siberia, is first lodged in a district prison, whence he is transferred to a government prison. The transportation to Siberia is carried on by railroad and boats to Tobolsk, where a division of the gang takes place, and destinations are appointed for the prisoners according to the character of their offenses. Those who have been condemned to death, and had their sentences commuted to exile, are bound with chains and all sent together to the mines of the Altai. Formerly the convicts were driven in gangs, chained about two feet apart. So at least I have read and heard it generally believed. I was once myself a witness of a spectacle of this kind, but it was not

in Russia nor in Siberia, but in Olmütz, in Austria, in the year of grace 1872. The worst part of the journey is when the steamers come into requisition. They are long boats with a high deck, designed to carry six hundred persons at once. The deck is inclosed and covered with strong grating, in order to prevent any attempts to escape. Fore and aft of these are the kitchens and hospitals, while the six hundred convicts are confined in a mass under the deck in a space which is far too narrow, and where, for lack of efficient ventilation, a stifling atmosphere always prevails. The Russian law allows a divorce to the wives of convicts sentenced to exile, but the communes, on the other hand, are anxious to cast off the burden of their possibly pauper families, and the government encourages this disposition by permitting the wives and children of the exiles to go with them. In most cases, the families are ready to share the fate of the father; the Jewish wife always goes with her husband. The relatives are also sent off with the prisoner. This measure has evil consequences on the vessels, where, as we have said, six hundred persons, including those of the worst character, are crowded into a single apartment, and can see, hear, and talk with one another at every hour of the day and night. When we consider that many children are mingled with the crowd, we can easily conceive what horrible scenes besides the physical torments are enacted there, and how brutalizing must be the impression they make upon young and old. In such cases the reproach of inhumanity against the government is fully justified, and it is not spared, for I have frequently heard the officers condemn the decrees of the courts. The journey by steamer requires ten times less time, but it is also ten times worse, more degrading, and more barbarous than the march on foot. When the change is made from the steamer to the railroad the situation assumes a little better shape. The prisoners, with their wives and children around them, cling to the benches along the bare walls, and the chains clink weirdly in the confusion of screaming, moaning, and cursing voices. Here also is a deficiency of space and air, and the conditions are hardly endurable. But the few observations of strangers are contradicted by the stereotyped view. "The farmers do not travel differently, and what they freely endure for themselves certainly ought to be good enough for criminals." Gangs on foot are still usual, but only the strongest men are taken in them, and the treatment is more humane than it was. The average day's journey is about seven geographical miles, and every third day is a rest-day. Complaints may be heard that seven miles a day is too much, but it seems to be forgotten that the soldier has to perform the same march, and he is encumbered with his baggage. At the present time the deportation takes place only in the summer, and the exiles are settled before the approach of winter.

At the beginning of the journey, each prisoner is given a gray cloak, and he receives daily for his maintenance from ten to fifteen

copecks, about from five and two thirds to eight and a half cents. This may seem very little in our conception, but it must not be forgotten that the men are permitted to beg on the way and to work on the rest-days, whereby each one may, if he will, obtain a considerable addition to his allowance. Great sympathy is felt in Siberia with the prisoners, who are never called by any other name than "unfortunates." Every one gives readily, and recollects that he himself, perhaps, or his father or grandfather, may have made the journey thither under similar circumstances. On the whole, transportation on foot is now quite well conducted. Such a journey can not be called a pleasure-trip, but it does not in any way bear the stamp of inhumanity and the terrible character which the sensational reports would impute to it.

Finally, the prisoner has reached his destination, either alone or with his wife and children, and is allotted accordingly a larger or smaller hut for a dwelling—I am speaking particularly of those who had been condemned to death. The chains are not taken off from his hands and feet, but he must work with them on. It often happens that he dies shortly—that is his luck; or that he will not accommodate himself to the situation, and leads a wretched existence, and finally goes to ruin, unless he has energy enough left to escape. He is himself committed to the most arduous exertions to better his fate, but, of the thousands and thousands who arrive there, only a very small per cent have the earnest will to do it. The great majority brood over their lot, and think and dream only about the ways and means of bringing about their escape. The convicts are mingled in work with the free laborers, go in and out with them, and do not have to exert themselves any more or do any harder work than they. The mine is not a prison as we are accustomed to regard prisons. The convict lives free and unwatched, alone or with his family, and the only limitation of freedom imposed upon him consists in his being always shackled with chains, whether at work or at recreation, by day and by night, and in his never being allowed to go out of the bounds that are assigned to him. In a district of six thousand square versts (about eight hundred and sixty geographical square miles), there are only a hundred soldiers stationed to watch the thousands of convicts. Escape under these circumstances is easy, and is a daily event. No one runs away alone; they generally go in pairs, and after careful preparation. The mine-smith is always ready, for a fee of ten copecks, to be a help in time of need and take off the chains. The fugitives gather up whatever seems useful to them, and travel under cover of darkness on their hazardous journey. On the next morning the director mentions the fact that A and B have disappeared. "No matter," he coolly remarks, and with that the affair is over for him. The fugitives spend the first three or four days in the woods, traveling at night, when they can pass on the highways undisturbed, and will

rarely have to take the trouble to hide themselves. More than once have we met such desperadoes on the road, been begged from and given, in regular Siberian style. If a police-officer casually comes in the way, he will offer his mite very quietly, without asking a question. "Let them go, it's no matter," is the refrain of the officers. The farmers take the best of care of the fugitives, and that quite systematically. At night, before bedtime, provisions for any passing "unfortunates" are placed at the windows in all the villages on the roads leading to Russia. When a pair of such men come into the village, they go around from house to house, take the food they find set out, as much as they want, with a little provision for the road, and proceed to the bath-house, at the end of the village, where it is always pleasantly warm, to sleep; and this they do with the greatest security, for they know that, in case of danger from the military patrol, the nearest farmer will send his son or a servant to the bath-house to warn any "unfortunates" that may be lodging there. The farmer is the providence of these people.

After the fugitives have put a distance of one hundred and fifty or two hundred miles between themselves and the mines, the journey becomes easier and they appear more openly. They can venture to ask for a lodging from any of the farmers, and to take horses from the back of the village and ride on them to the next village. There they will unbridle the beasts and start them back toward where they came from, mount fresh horses, and so on for hundreds and hundreds of miles. But the horses are every time carefully started back to their homes. Everything goes smoothly, and the sympathy of the people is inexhaustible, so long as the "unfortunate" does not steal. As soon as he appropriates the smallest portion of strange goods, he seals his fate. The whole village turns out and pursues the thief, who is beaten down like a dog, wherever and whenever he is found; and he is always found. The result of this inexorable popular justice is, that hardly any thieves are to be found in Siberia, and that no country enjoys greater security than this colony of criminals. But, one may ask, "Are not the people punished who execute this lynch-law?" It must be remembered that the mining district embraces an area at least five times as large as that of the State of New York, that the population is relatively small, and that in most cases no one cares for slain fugitives. If the officers are informed of the occurrence, they will simply remark that no harm has been done. The report is sent to St. Petersburg, and is lost in the flood of similar documents. The escape of convicts is, as we have remarked, a daily event, and it is of little consequence to the magistrates whether one more or less has been captured or killed. Of the fifteen thousand prisoners annually brought into the district, an average of five thousand escape. These are the desperate ones who stake everything to obtain freedom again. If they are brought back, they flee again. The number of those who escape two or three or more times,

and are brought back as often, is great; and many "unfortunates" spend the last days of their lives in trying to get back to Russia, and being retransported to the colony.

This is the shadow-side of the convict's existence: I will now briefly sketch the bright side. A convict, who has become skilled in mining, repents of his offense, submits to his fate, works industriously, and conducts himself well in every respect, and ventures in time to open his heart to the director and ask to have his situation improved. The officer encourages him, gives him good advice, and permits him, after he has suffered three, four, or five years of punishment, to have his chains replaced by lighter ones, and, when he is convinced that the man is really reformed, grants him a settlement. Thus the prisoner has become a free man, except that he is never permitted to leave the district to which he is assigned. Now, the advantage of the system that permits the family of the prisoner to go with him to the place of punishment is manifested. The man has, during his long years of hard labor, been with his wife and children, has gained courage and strength in this family life, and has become a good man. The presence of his family has been a blessing to him. When in other countries the doors of the prison close upon a condemned man, the world is no more to him—all connection between him and his is severed; while to the Russian prisoner is left the comfort of his family, a strong anchor that holds his heart fast against the tumult of his sufferings. The released miner goes with his family to the settlement which has been designated for him. He has nothing but the bare land, his own strong will, and his energy inured to suffering. The village must extend a hand to him and advance the means for setting up an independent establishment. He is furnished a house—of course a very poor one—farming-tools, seed-corn, and a start in live-stock. Now, he begins a new life. After the first harvest is gathered, and what is necessary for his bare support has been reserved, he goes bravely to work to discharge his obligations to the commune. After ten years at latest, he will have made good to the last grain of corn, and he then becomes the owner of an estate free of debt, for which he has only to pay a small ground-rent, and has the satisfaction of knowing that after his death his children will be free men in a home founded by him.

Now, how does the condition of a person discharged from prison in one of the so-called civilized countries compare with that of this Siberian? The last spark of self-respect that may be left in him is extinguished by the reception society gives him. Contempt, suspicion, and scorn meet him at every step. Neither Government nor society will give him the means of rehabilitating himself by labor and of founding a new existence, and he sinks deeper and deeper, with no way of escape open to him, into crime and ever again into crime.

Pardoned convicts or their children are living in nearly every town and village of the Altai region, and this fact is the origin of the

most curious relations. I sojourned for a short time at an inn in Tomsk. The host and his wife made an unfavorable, I might say a repulsive, impression upon me. I could not refrain from expressing my suspicions to the chief of police, to whom I had been introduced. To my edification I learned that the host had been condemned to twenty-five years in prison for fraudulent bankruptcy, and his wife to twenty years as his accessory ; that the porter was an old house-breaker, and the four butlers had been compelled to take the involuntary tour to the East for thefts ; the two maids were child-murderers ! Such is the environment in which the people of that district constantly live. On the next day I dined by invitation with a merchant. I met a polite, cultivated company, and learned afterward from my friend the police-officer that the apothecary, who sat next to me, had been transported for poisoning, that three of the guests were fraudulent directors of exploded banks, and two were counterfeiters ! The last two had made a bad impression on me from the beginning, and I could not afterward repress the thought that they were continuing in Siberia to increase as much as they could the circulation of cash in the Russian Empire. If one expresses surprise at such social conditions, the answer is, " Oh, please remember that we are in Siberia ! " It is, moreover, not considered necessary to avoid speaking of these matters with reference to any one. The party concerned himself will converse on the subject with the greatest ease, and his frankness respecting it is really astonishing. I inquired one day in a matter-of-course-way of a Jew named Ephraim, who carried on a small banker's business, a very prepossessing man socially, how he came to settle there. He replied jestingly, and with a wink : " Circumstances are to blame for that ; they compelled me to establish my business here some two-and-twenty years ago."

Real prisons with locks and walls are comparatively rare in Siberia, and form in all cases, unless the positively evil disposition of the convict prolongs his stay, a transitional abode between the unlimited freedom he enjoyed before his offense and the limited freedom that follows his sentence. Offenders are not cast into narrow cells for the full term of their punishment, but go around free after a short confinement, and are supported by the contributions of their former colleagues, while they are afforded full opportunity to found a new existence. The contrasts between the positions which released prisoners may attain in Siberia and the offense which led to their exile are frequently quite comical. The child-murderer becomes a trusted nurse, the burglar an overseer, the thief a confidential servant ! But a practical Christianity is exercised toward the fallen one. The Government and private persons rival one another in pointing out and clearing the way of reform for the wanderer. In Kazmetak, we visited the local prison, which is unique in its way. It was of immense capacity, and was so arranged as to permit a complete separa-

tion of the several confessions—Mohammedans, Jews, and Christians. All the prisoners assured us that they had no complaints to make. The few political prisoners confirmed these statements, so that their condition, too, must certainly have been endurable; for it is well known that the political prisoners are the most discontented. A school is connected with the prison, in which a young priest was serving as teacher; the only text-book was a Russian catechism, which was used by Mohammedans and Jews as well as by Christians. The great point was that all learned to read and write. The priest received no pay, but was performing a work of mercy. In the same place are a hospital for the sick and an orphan-house for the children of those convicts whose imprisonment is prolonged. The foundation of this institution was the work of a lady who gave her whole fortune to it, and then devoted herself to the solicitation of means for its support.

When one has studied these conditions on the spot, and has satisfied himself that while the situation of the prisoner condemned to death and pardoned to the mines is hard, it nevertheless depends upon himself whether he shall improve it and make his children free, independent, and prosperous citizens; when one sees how the opportunity is given to all convicts, without distinction as to what their crime may have been, to found by their own exertions a new and honorable career, and that the Government aids the earnest efforts of such persons with counsel and act; when one, finally, contrasts the magnanimity, fidelity, and touching sympathy, existing among private persons, with the sad lot of convicts in Europe and America, he will have to admit that there may be worse countries than Siberia.

HOW SPELLING DAMAGES THE MIND.

By FREDERIK A. FERNALD.

LEARNING to read the English language is one of the worst mind-stunting processes that has formed a part of the general education of any people. Its evil influence arises from the partly phonetic, partly lawless character of English spelling. Although each letter represents some sound oftener than any other, there is hardly a letter in the alphabet that does not represent more than one sound, and hardly a sound in the language that is not represented in several ways, while many words are written with as many silent letters as significant ones. There is nothing in any word to indicate in which of these ways its component sounds are represented, nothing in the written group of letters to show which sounds they stand for, and which of them, if any, are silent, so that a learner

can never be sure of pronouncing rightly an English word that he has not heard spoken, nor of spelling correctly one that he has never seen written. The spelling of each word must be learned by sheer force of memory. In this work the pupil's reasoning powers can not be utilized, but must be subdued, while his memory is sadly overworked. In the affairs of the child's daily life, the logical following out of rules is rewarded; in learning to spell, it brings him only discomfiture and bewilderment. He is taught that *b-o-n-e* stands for *bōn* (not *bo-ne*), and *t-o-n-e* for *tōn*, but that *d-o-n-e* stands for *dun*, that *g-o-n-e* spells *gŏn*, *m-o-v-e* spells *moov*, and *b-r-o-n-z-e bronz*. Now when he comes in reading to another similar word, as *none*, he has no means of telling whether to call it *nōn*, *nun*, *nŏn*, *noon*, or *non*; he can only look up at his teacher and wait to be told. The influence of the spelling-class quickly drives him to repress any inclination to reason, and he gives himself up to a blind following of authority. No child learns English spelling without getting the pernicious notion that cram is better than thinking, and that common sense is a treacherous guide. The child who can take what he is told without asking why, who can repeat a rule without troubling himself about its meaning, gets along best. On the other hand, the child who has difficulty in learning to spell may be expected to develop strong logical faculties. He is constantly trying to spell according to some principle, and, of course, constantly coming to grief. Thus a boy who had long been at the foot of his spelling-class was one day given the word *ghost*, and, making a desperate attempt at the sort of spelling he had oftenest heard succeed, he spelled it *g-h-o-g-h-j-s-t*. This bringing upon him shouts of laughter, he said, with clinched fist and tearful eyes: "You needn't laugh; you all spell homelier 'n that!" So much attention is given to spelling that children obtain false ideas of its importance. The *spelling*, or representation, becomes to them the word, while the real *word* is called the pronunciation, and is thought of as an appendage. They learn to despise the poor speller, a prejudice which is never outgrown, and above all they become so absorbed in the manipulation of words that they have little chance to grasp the ideas which the words stand for.

If our notation of numbers were as irregular as our notation of speech, so that the numbers from forty to forty-five, for instance, should be written, say as follows: 40, 741, 420, 43, 414, 225; and if no one could tell at sight whether a number like 7,243,812 contained several figures which were "silent," or had exceptional values, who can doubt that the study of arithmetic, instead of being a valuable discipline, would be mere mentally enervating drudgery? If it were proposed that children should learn a style of writing music which gave different values to the same characters, similarly placed, in different pieces, and added a host of "silent" notes, the evils of learning such a system would be plainly seen. Yet many people, who have

forgotten their own sufferings in the spelling-class, can not see that children are so very much perplexed in learning to spell, or perhaps maintain that the struggle involved is "good for them."

"I know," says Max Müller, "there are persons who can defend anything, and who hold that it is due to this very discipline that the English character is what it is; that it retains respect for authority; that it does not require a reason for everything; and that it does not admit that what is inconceivable is therefore impossible. Even English orthodoxy has been traced back to that hidden source, because a child accustomed to believe that *t-h-o-u-g-h* is *though*, and that *t-h-r-o-u-g-h* is *through*, would afterward believe anything. It may be so; still I doubt whether even such objects would justify such means. Lord Lytton says: 'A more lying, roundabout, puzzle-headed delusion than that by which we confuse the clear instincts of truth in our accursed system of spelling was never concocted by the father of falsehood. . . . How can a system of education flourish that begins by so monstrous a falsehood, which the sense of hearing suffices to contradict?'"

Here is a chief source of the incapacity for thinking which academy and college students bring into the science laboratories. This irrational process, taken up when the child enters school, occupying a large share of his time, and continued for six or eight years, has a powerful influence in shaping his plastic mind. When at last he is allowed to take up the study of nature, at the wrong end of his school course, what wonder that he sits with folded hands, waiting to be told facts to commit to memory, that he can not realize what a law is, and does not know how to use his reason in obtaining knowledge? Rational education will never flourish as it should till a reformation in the teaching of reading and spelling has been accomplished. Further, Mr. J. H. Gladstone, member of the English School Board for London, has computed the number of hours spent by children in learning to read and spell English to be 2,320, while, in gaining an equal knowledge of their native language, Italian children spend only 945 hours. The difference amounts to nearly two school years, and shows under what a disadvantage English-speaking children labor. Can any one believe that 4,923,451, or 13·4 per cent, of our population over ten years of age would be illiterate if learning to read were not so formidable an undertaking? In Norway, Sweden, Denmark, Switzerland, and some German states, there are hardly any illiterates.

The most striking testimony to the irregularity of our spelling is the adoption by some teachers of a sort of Chinese mode of teaching reading. The children are not taught that letters represent constituent sounds of words, but they learn to recognize each group of letters as an arbitrary compound symbol standing for a word. This is more of a dead drag on the memory than even the A-B-C method, and, if it could be completely carried out, would be a vastly longer process.

The effect on the mind is certainly no better. The Chinese have to memorize a compound symbol for each word in learning to read, but the patient endurance of such a burden is not consistent with the character of any other people than the submissive, imitative, unprogressive Chinese. The Japanese, who have long been clogged by the same system, have recently taken measures to throw it off.

"But what can be done?" will be asked; "shall children grow up without learning to spell?" No, but the memorizing of these anomalies and contradictions can be, at least, put off till the pupils' minds are in little danger of being perverted by it. Enough of the enormous amount of time spent in this drudgery can be saved to make possible the introduction of the study of *things* into the primary schools, and many of the one hundred millions of dollars which we spend each year for public education can be turned to imparting real knowledge instead of the mere tools of knowledge. These ends may be attained by the use of phonetic spelling as an introduction to the customary spelling. Children can and do learn to read English spelled phonetically in a very few lessons, and learn the traditional spelling so quickly afterward that much less time is required for the whole process than is commonly devoted to memorizing the current spelling alone. Classes taught to read in this way, in Massachusetts, so early as 1851, proved the advantage of the method to the satisfaction of that able educator, Horace Mann, and the method has been successfully employed in many places in this country and in the British Isles. The following extract from a letter written by Mr. William Colbourne, manager of the Dorset Bank, at Sturminster, England, since deceased, furnishes a special example, though it may be conceded to be exceptionally favorable:

"My little Sidney, who is now a few months more than four years old, will read any phonetic book without the slightest hesitation; the hardest names or the longest words in the Old or New Testament form no obstacle to him. And how long do you think it took me—for I am his teacher—to impart to him this power? Why, something less than eight hours! You may believe it or not as you like, but I am confident that not more than that amount of time was spent on him, and that was in snatches of five minutes at a time, while tea was getting ready. I know you will be inclined to say: 'All that is very well, but what is the use of reading phonetic books? He is still as far off, and may be farther, from reading romanic books.' But in this you are mistaken. Take another example. His next elder brother, a boy of six years, has had a phonetic education so far. What is the consequence? Why, reading in the first stage was so delightful and easy a thing to him, that he *taught himself* to read romanically, and it would be a difficult matter to find one boy in twenty, of a corresponding age, that could read half so well as he can in any book. Again, my oldest boy has written more phonetic short-

hand and long-hand, perhaps, than any boy of his age (eleven years) in the kingdom; and no one I dare say has had less to do with that absurdity of absurdities, the spelling-book! He is now at a first-rate school in Wiltshire, and in the half-year preceding Christmas he carried off the prize for *orthography* in a contest with boys, some of them his senior by years!"

Mrs. E. B. Burnz, of New York, says, in regard to her experience at Nashville, soon after the civil war: "The phonetic teaching in the Fisk School, as elsewhere, proved beyond all cavil that with phonetic books as much could be accomplished in four months in teaching to read as by a year with the common method. And, moreover, it showed that there is no difficulty experienced by children in passing from the phonetic to the ordinary printed books. After going through the phonetic primer and First and Second Reader, the children passed at once into the Second Reader in common print, and from the phonetic Gospel into the common New Testament." Successful experiments in common schools are on record in sufficient numbers to prove the practicability of the method.

Several phonetic primers have been published and are used in some American and English schools, for teaching English in the schools of Paris, and by missionaries among the Indians and other peoples. With one of these books, parents will find it a light task to teach their children to read at home in a few lessons. Since there are only twenty-six (or, counting æ and œ, twenty-eight) letters in our alphabet, while for phonetic printing means of representing forty sounds are needed, each of these books uses an extended form of the alphabet. Unfortunately, no one alphabet for the phonetic printing of English has yet been agreed upon; still, any of these systems can be adopted for the schools of a city or town, with the certainty of good results. The alphabet devised by the American Philological Association may be said to be the most authoritative; it has also the merit of employing only three new letters. I am not unaware of the efforts being made to replace the current spelling by a phonetic system for all purposes, but that is a matter quite distinct from the subject of this article; and all who believe that the orderly and vigorous development of the mental faculties should be the chief end in education, whether they favor or oppose the spelling reform, can work together for the spread of the phonetic method of teaching reading.

SUNLIGHT AND THE EARTH'S ATMOSPHERE.*

By Professor S. P. LANGLEY.

THERE is, we may remember, a passage in which Plato inquires what would be the thoughts of a man who, having lived from infancy under the roof of a cavern, where the light outside was inferred only by its shadows, was brought for the first time into the full splendors of the sun.

We may have enjoyed the metaphor without thinking that it has any physical application to ourselves, who appear to have no roof over our heads, and to see the sun's face daily; while the fact is, that if we do not see that we have a roof over our heads in our atmosphere, and do not think of it as one, it is because it seems so transparent and colorless.

Now, I wish to ask your attention to-night to considerations in some degree novel, which appear to me to show that it is not transparent as it appears, and that this seeming colorlessness is a sort of delusion of our senses, owing to which we have never in all our lives seen the true color of the sun, which is in reality blue rather than white, as it looks, so that this air all about and above us is acting like a colored glass roof over our heads, or a sort of optical sieve, holding back the excess of blue in the original sunlight, and letting only the white sift down to us.

I will first ask you, then, to consider that this seeming colorlessness of the air may be a delusion of our senses, due to habit, which has never given us anything else to compare it with.

If that cave had been lit by sunshine coming through a reddish glass in its roof, would the perpetual dweller in it ever have had an idea but that the sun was red? How is he to know that the glass is "colored" if he has never in his life anything to compare it with? How can he have any idea but that this is the sum of all the sun's radiations (corresponding to our idea of white or colorless light); will not the habit of his life confirm him in the idea that the sun is red; and will he not think that there is no color in the glass so long as he can not go outside to see? Has this any suggestion for us, who have none of us ever been outside our crystal roof to see?

We must all acknowledge, in the abstract, that habit is equally strong in us, whether we dwell in a cave or under the sky; that what we have thought from infancy will probably appear the sole possible explanation; and that, if we want to break its chain, we should put ourselves, at least in imagination, under conditions where it no longer binds us.

* A lecture delivered at the Royal Institution of Great Britain, Friday evening, April 17, 1885.

The Challenger has dredged from the bottom of the ocean fishes which live habitually at great depths, and whose enormous eyes tell of the correspondingly faint light which must have descended to them through the seemingly transparent water. It will not be as futile a speculation as it may at first seem, to put ourselves in imagination in the condition of creatures under the sea, and ask what the sun may appear to be to them; for, if the fish who had never risen above the ocean-floor were an intelligent being, might *he* not plausibly reason that the dim greenish light of his heaven—which is all he has ever known—was the full splendor of the sun shining through a medium which all his experience shows is transparent?

We ourselves are, in very fact, living at the floor of a great aërial sea, whose billows roll hundreds of miles above our heads. Is it not at any rate conceivable that we may have been led into a like fallacy from judging only by what we see at the bottom? May we not, that is, have been led into the fallacy of assuming that the intervening medium above us is colorless because the light which comes through it is so?

I freely admit that all men, educated or ignorant, appear to have the evidence of their senses that the air is colorless, and that pure sunlight is white, so that if I venture to ask you to listen to considerations which have lately been brought forward to show that it is the sun which is blue, and the air really acts like an orange veil or like a sieve which picks out the blue and leaves the white, I do so in the confidence that I may appeal to you on other grounds than those I could submit to the primitive man who has his senses alone to trust to; for the educated intelligence possesses those senses equally, and in addition the ability to interpret them by the light of reason, and before this audience it is to that interpretation that I address myself.

Permit me a material illustration. You see through this glass, which may typify the intervening medium of air or water, a circle of white light, which may represent the enfeebled disk of the sun when so viewed. Is this intervening glass colored or not? It seems nearly colorless; but have we any right to conclude that it is so because it seems so? Are we not *taking it for granted* that the original light which we see through it is white, and that the glass is colorless, because the light seems unaltered; and is not an appeal to be made here from sense to reason, which, in the educated observer, recalls that white light is made of various colors, and that whether the original light is really white and the glass transparent, or the glass really colored and so *making* the white, is to be decided only by experiment, by taking away the possibly deceptive medium? I can take away this glass, which was not colorless, but of a deep orange, and you see that the original light was not white, but intensely blue. If we could take the atmosphere away between us and the sun, how can we say that the same result might not follow? To make the meaning of our illustra-

tion clearer, observe that this blueness is not a pure spectral blue. It has in it red, yellow, blue, and all the colors which make up white, but blue in superabundance ; so that, though the white is, so to say, latent there, the dominant effect is blue. The glass colored veil does not put anything *in*, but acts I repeat like a sieve straining *out* the blue, and letting through to us the white light which was there in the bluishness, and so may not our air do so too ?

I think we already begin to see that it is at any rate conceivable that we *may* have been hitherto under a delusion about the true color of the sun, though of course this is not proving that we have been so, and it will at any rate, I hope, be evident that here is a question raised which ought to be settled, for the blueness of the sun, if proved, evidently affects our present knowledge in many ways, and will modify our present views in optics, in meteorology, and in numerous other things. In optics, because we should find that white light is *not* the sum of the sun's radiations, but only of those dregs of them which have filtered down to us ; in meteorology, because it is suggested that the temperature of the globe and the condition of man on it depend in part on a curious selective action of our air, which picks out parts of the solar heat (for instance, that connected with its blue light), and holds them back, letting other selected portions come to us, and so altering the conditions on which this heat by which we live depends ; in other ways, innumerable, because, as we know, the sun's heat and light are facts of such central importance that they affect almost every part of scientific knowledge.

It may be asked, What suggested the idea that the sun may be blue rather than any other color ?

My own attention was first directed this way many years ago when measuring the heat and light from different parts of the sun's disk. It is known that the sun has an atmosphere of its own which tempers its heat, and, by cutting off certain radiations and not others, produces the spectral lines we are all familiar with. These lines we customarily study in connection with the absorbing vapors of sodium, iron, and so forth, which produce them ; but my own attention was particularly given to the regions of absorption, or to the color it caused, and I found that the sun's body must be deeply bluish, and that it would shed blue light except for this apparently colorless solar atmosphere, which really plays the part of a reddish veil, letting a little of the blue appear on the center of the sun's disk where it is thinnest, and staining the edge red, so that to delicate tests the center of the sun is a pale aqua-marine, and its edge a garnet. The effect I found to be so important, that if this all but invisible solar atmosphere were diminished by but a third part, the temperature of the British Islands would rise above that of the torrid zone, and this directed my attention to the great practical importance of studying the action of our own terrestrial atmosphere on the sun, and the antecedent probability that our

own air was also and independently making the really blue sun into an apparently white one. We actually know, then, beyond conjecture, by a comparison of the sun's atmosphere, where it is thickest and where it is thinnest, that an apparently colorless atmosphere *can* have such an effect, and analogous observations which I have carried on for many years, but do not now detail, show that the atmosphere of our own planet, this seemingly clear air in which we exist like creatures at the bottom of the sea, does do so.

We look up through our own air as through something so limpid in its purity that it appears scarcely matter at all, and we are apt to forget the enormous mass of what seems of such lightness, but which really presses with nearly a ton to each square foot, so that the weight of all the buildings in this great city, for instance, is less than that of the air above them.

I hope to shortly describe the method of proof that it too has been acting like an optical sieve, holding back the blue; but it may naturally be asked, "Can our senses have so entirely deceived us that they give no hint of this truth, if it be one? is the appeal wholly to recondite scientific methods, and are there no indications, at least, which we may gather for ourselves?" I think there are, even to our unaided eyes, indications that the seemingly transparent air really acts as an orange medium, and keeps the blue light back in the upper sky.

If I hold this piece of glass before my eyes, it seems colorless and transparent, but it is proved not to be so by looking through it edgewise, when the light, by traversing a greater extent, brings out its true color, which is yellow. Every one knows this in every-day experience. We shall not get the color of the ocean by looking at it in a wine-glass, but by gazing through a great depth of it; and so it is with the air. If we look directly up, we look through where it is thinnest; but, if we look horizontally through it toward the horizon, through great thicknesses, as at sunrise or sunset, is it not true that this air, where we see its real color most plainly, makes the sun look very plainly yellow or orange?

We not only see here, in humid English skies, the "orange sunset waning slow," but most of us in these days of travel can perfectly testify that the clearest heavens the earth affords, the rosy tint on the snows of Mont Blanc, forerunning the dawn, or the warm glow of the sun as he sets in Egyptian skies, show this most clearly—show that the atmosphere holds back the blue rays by preference, and lets the orange through.

If, next, we ask, "What has become of the blue that it has stopped?" does not that very blue of the midday sky relate the rest of the story—that blue which Professor Tyndall has told us is due to the presence of innumerable fine particles in the air, which act selectively on the solar waves, diffusing the blue light toward us? I hope it will be understood that Professor Tyndall is in no way responsible for my own

inferences ; but I think it is safe at least to say that the sky is not self-luminous, and that, since it can only be shining blue at the expense of the sun, all the light this sky sends us has been taken by our atmosphere away from the direct solar beam, which would grow both brighter and bluer if this were restored to it.

If all that has been said so far renders it possible that the sun may be blue, you will still have a right to say that "possibilities" and "may-bes" are not evidence, and that no chain of mere hypotheses will draw Truth out of her well. We are all of one mind here, and I desire next to call your attention to what I think is evidence.

Remembering that the case of our supposed dweller in the cave who could not get outside, or that of the inhabitants of the ocean-floor who can not rise to the surface, is really like our own, over whose heads is a crystalline roof which no man from the beginning of time has ever got outside of, an upper sea to whose surface we have never risen—we recognize that if we could rise to the surface, leaving the medium whose effect is in dispute wholly beneath us, we should see the sun as it is, and get proof of an incontrovertible kind ; and that, if we can not entirely do this, we shall get nearest to proof under our real circumstances by going as high as we can in a balloon, or by ascending a very high mountain. The balloon will not do, because we have to use heavy apparatus requiring a solid foundation. The proof to which I ask your kind attention, then, is that derived from the actual ascent of a remarkable mountain by an expedition undertaken for that purpose, which carried a whole physical laboratory up to a point where nearly one half the whole atmosphere lay below us. I wish to describe the difference we found in the sun's energy at the bottom of the mountain and at the top, and then the means we took to allow for the effect of that part of the earth's atmosphere still over our heads even here, so that we may be said to have virtually got outside it altogether.

Before we begin our ascent, let me explain more clearly what we are going to seek. We need not expect to find that the original sunlight is a pure monochromatic blue by any means, but that, though its rays contain red, orange, blue, and all the other spectral colors, the blue, the violet, and the allied tints were originally there in disproportionate amounts, so that, though all which make white were present from the first, the refrangible end of the spectrum had such an excess of color that the dominant effect was that of a bluish sun. In the same way, when I say briefly that our atmosphere has absorbed this excess of blue and let the white reach us, I mean, more strictly speaking, that this atmosphere has absorbed *all* the colors, but, selectively, taking out more orange than red, more green than orange, more blue than green ; so that its action is wholly a taking *out*—an action like that which you now see going on with this sieve, sifting a mixture of blue and white beads, and holding back the blue while letting the white fall down.

This experiment only rudely typifies the action of the atmosphere, which is discriminating and selective in an amazing degree, and, as there are really an infinite number of shades of color in the spectrum, it would take forever to describe the action in detail. It is merely for brevity, then, that we now unite the more refrangible colors under the general word "blue," and the others under the corresponding terms "orange" or "red."

All that I have the honor to lay before you is less an announcement of absolute novelty than an appeal to your already acquired knowledge, and to your reason as superior to the delusions of sense. I have, then, no novel experiment to offer, but to ask you to look at some familiar ones in a new light.

We are most of us familiar, for instance, with that devised by Sir Isaac Newton to show that white light is compounded of blue, red, and other colors, where, by turning a colored wheel rapidly, all blend into a grayish white. Here you see the "seven colors" on the screen; but, though all are here, I have intentionally arranged them so that there is too much blue, and the combined result is a very bluish white which may roughly stand for that of the original sun-ray. I now alter the proportion of the colors so as to virtually take out the excess of blue, and the result is colorless or white light. White, then, is not necessarily made by combining the "seven colors," or any number of them, unless they are there in just proportion (which is in effect what Newton himself says); and white, then, may be made out of such a bluish light as we have described, not by putting anything to it, but by taking away the excess which is there already.

Here, again, are two sectors—one blue, one orange-yellow with the blue in excess, making a bluish disk where they are revolved. I take out the excess of blue, and now what remains is white.

Here is the spectrum itself on the screen, but a spectrum which has been artificially modified so that the blue end is relatively too strong. I recombine the colors (by Professor Rood's ingenious device of an elastic mirror), and they do not make a pure white, but one tinted with blue. I take out the original excess of blue, and what remains combines into a pure white. Please bear in mind that, when we "put in" blue here, we have to do so by straining out other light through some obscuring medium, which makes the spectrum darker; but that, in the case of the actual sunlight, introducing more blue introduces more light and makes the spectrum brighter.

The spectrum on the screen ought to be made still brighter in the blue than it is—far, far brighter—and then it might represent to us the original solar spectrum before it has suffered any absorption either in the sun's atmosphere or our own. The Fraunhofer lines do not appear in it, for these, when found in the solar spectrum, show that certain individual rays have been stopped, or selected for absorption by the intervening atmospheres; and, though even the few yards of

atmosphere between the lamp and the screen absorb, it is not enough to show.

Our spectrum, as it appears before absorption, might be compared to an army divided into numerous brigades, each wearing a distinct uniform, one red, one green, one blue, so that all the colors are represented each by its own body. If, to represent the light absorbed as it progresses, we supposed that the army advances under a fire which thins its numbers, we should have to consider that (to give the case of nature) this destructive fire was directed chiefly against those divisions which were dressed in blue, or allied colors, so that the army was thinned out unequally, many men in blue being killed off for one in red, and that by the time it has advanced a certain distance under fire the proportion of the men in each brigade has been altered, the red being comparatively unhurt. Almost all absorption is thus selective in its action, and often in an astonishing degree, killing off, so to speak, certain rays in preference to others, as though by an intelligent choice, and destroying most, not only of certain divisions (to continue our illustration), but even picking out certain files in each company. Every ray, then, has its own individuality, and on this I can not too strongly insist; for just as two men retain their personalities under the same red uniform, and one may fall and the other survive, though they touch shoulders in the ranks, so in the spectrum certain parts will be blotted out by absorption, while others next to them may escape.

To illustrate this selective absorption, I put a piece of didymium glass in the path of the ray. It will, of course, absorb some of the light, but, instead of dimming the whole spectrum, we might almost say it has arbitrarily chosen to select one narrow part for action, in this particular case choosing a narrow file near the orange, and letting all the rest go unharmed. In this arbitrary way our atmosphere operates, but in a far more complex manner, taking out a narrow file here and another there, in hundreds of places, all through the spectrum, but on the whole much the most in the blue, the Fraunhofer lines being merely part of the evidence of this wonderful *quasi*-intelligent action which bears the name of selective absorption.

Before we leave this spectrum, let us recall one most important matter. We know that here beyond the red is solar energy in the form of heat which we can not see, but not on that account any less important. More than half the whole power of the sun is here invisible, and, if we are to study completely the action of our atmosphere, we shall have to pay great attention to this part, and find out some way of determining the loss in it, which will be difficult, for the ultra-red end is not only invisible, but compressed, the red end being shut up like the closed pages of a book, as you may notice by comparing the narrowness of the red with the width of the blue.

Now, refraction by a prism is not the only way of forming a spectrum. Nature furnishes us color not only from the rainbow, but from

non-transparent substances like mother-of-pearl, where the iridescent hues are due to microscopically fine lines. Art has lately surpassed Nature in these wonderful "gratings," consisting of pieces of polished metal, in which we see at first nothing to account for the splendid play of color apparently pouring out from them like light from an opal, but which, on examination with a powerful microscope, show lines so narrow that there are from fifty to one hundred in the thickness of a fine human hair, and all spaced with wonderful precision.

This grating is equal in defining power to many such prisms as we have just been looking at, but its light does not show well upon the screen. You will see, however, that its spectrum differs from that of the prism, in that in this case the red end is expanded, as compared with the violet, and the invisible ultra-red is expanded still more, so that this will be the best means for us to use in exploring that "dark continent" of invisible heat found not only in the spectrum of the sun, but of the electric light, and of all incandescent bodies, and of whose existence we already know from Herschel and Tyndall.

Now, we can not reproduce the actual solar spectrum on the screen without the sun itself, but here are photographs of it, which show parts of the losses the different colors have suffered on their way to us. We have before us the well-known Fraunhofer lines, due, you remember, not only to absorption in the sun's atmosphere, but also to absorption in our own. We have been used to think of them in connection with their cause, one being due to the absorption of iron-vapor in the sun, another to that of water-vapor in our own air, and so forth; but now I ask you to think of them only in connection with the fact that each is due to the absorption of some part of the original *light*, and that collectively they tell much of the story of what has happened to that light on its way down to us. Observe, for instance, how much thicker they lie in the blue end than in the red—another evidence of the great proportionate loss in the blue.

If we could restore all the lost light in these lines, we should get back partly to the original condition of things at the very fount, and, so far as our own air is concerned, that is what we are to ascend the mountain for—to see, by going up through nearly half of the atmosphere, what the rate of loss is in each ray by actual trial; then, knowing this rate, to be able to allow for the loss in the other part still above the mountain-top; and, finally, by recombining these rays, to get the loss as a whole. Remember, however, always, that the most important part of the solar energy is in the dark spectrum which we do not see, but which, if we could see, we should probably find to have numerous absorption-spaces in it corresponding to the Fraunhofer lines, but where heat has been stopped out rather than light. To make our research thorough, then, we ought not to trust to the eye only, or even chiefly, but have some way of investigating the whole spectrum; the invisible in which the sun's power chiefly lies,

as well as the visible, and both with an instrument that would discriminate the energy in these very narrow spaces, like an eye to see in the dark; and if science possesses no such instrument, then it may be necessary to invent one.

The linear thermopile is nearest to it of any, and we all here know what good work it has done, but even that is not sensitive enough to measure in the grating spectrum, in some parts of which the heat is four hundred times weaker than in that of a prism, and we want to observe this invisible heat in very narrow spaces. Something like this has been provided since by Captain Abney's most valuable researches, but these did not at the time go low enough for my purpose, and I spent nearly a year before ascending the mountain in inventing and perfecting the new instrument for measuring these, which I have called the "bolometer" or "ray-measurer." The principle on which it is founded is the same as that employed by my late friend, Sir William Siemens, for measuring temperatures at the bottom of the sea, which is that a smaller electric current flows through a warm wire than through a cold one.

One great difficulty was to make the conducting wire very thin, and yet continuous, and for this purpose almost endless experiments were made, among other substances pure gold having been obtained by chemical means in a plate so thin that it transmitted a sea-green light through the solid substance of the metal. This proving unsuitable, I learned that iron had been rolled of extraordinary thinness in a contest of skill between some English and American iron-masters, and, procuring some, I found that fifteen thousand of the iron plates they had rolled, laid one on the other, would make but one English inch. Here is some of it, rolled between the same rolls which turn out plates for an ironclad, but so thin that, as I let it drop, the iron plate flutters down like a dead leaf. Out of this the first bolometers were made, and I may mention that the cost of these earlier experiments was met from a legacy by the founder of the Royal Institution, Count Rumford. The iron is now replaced by platinum, in wires or rather tapes from $\frac{1}{2000}$ to $\frac{1}{20000}$ of an inch thick, one of which is within this button, where it is all but invisible, being far finer than a human hair. I will project it on the screen, placing a common small pin beside it as a standard of comparison. This button is placed in this ebonite case, and the thread is moved by this micrometer-screw, by which it can be set like the spider line of a reticule; but by means of this cable, connecting it to the galvanometer, this thread acts as though sensitive, like a nerve laid bare to every indication of heat and cold. It is then a sort of sentient thing: what the eye sees as light it feels as heat, and what the eye sees as a narrow band of darkness (the Fraunhofer line) this feels as a narrow belt of cold, so that when moved parallel to itself and the Fraunhofer lines down the spectrum it registers their presence.

It is true we can see these in the visible spectrum, but you remember we propose to explore the invisible also, and since to this the dark is the same as the light, it will feel absorption lines in the infra-red which might remain otherwise unknown.

I have spent a long time in these preliminary researches; in indirect methods for determining the absorption of our atmosphere, and in experiments and calculations which I do not detail, but it is so often supposed that scientific investigation is a sort of happy guessing, and so little is realized of the labor of preparation and proof, that I have been somewhat particular in describing the essential parts of the apparatus finally employed, and now we must pass to the scene of their use.

We have been compared to creatures living at the bottom of the sea, who frame their deceptive traditional notions of what the sun is like from the feeble changed rays which sift down to them. Though such creatures could not rise to the surface, they might swim up toward it; and, if these rays grew hotter, brighter, and bluer as they ascended, it would be almost within the capacity of a fish's mind to guess that they are still brighter and bluer at the top.

Since we children of the earth, while dwelling on it, are always at the bottom of the sea, though of another sort, the most direct method of proof I spoke of is merely to group as far as we can and observe what happens, though as we are men, and not fishes, something more may fairly be expected of our intelligence than of theirs.

We will not only guess, but measure and reason, and in particular we will first, while still at the bottom of the mountain, draw the light and heat out into a spectrum, and analyze every part of it by some method that will enable us to explore the invisible as well as record the visible. Then we will ascend many miles into the air, meeting the rays on the way down, before the sifting process has done its whole work, and there analyze the light all over again, so as to be able to learn the different proportions in which the different rays have been absorbed, and, by studying the action on each separate ray, to prove the state of things which must have existed before this sifting—this selective absorption—began.

It may seem at first that we can not ascend far enough to do much good, since the surface of our aërial ocean is hundreds of miles overhead; but we must remember that the air grows thinner as we ascend, the lower atmosphere being so much denser that about one half the whole substance or mass of it lies within the first four miles, which is a less height than the tops of some mountains. Every high mountain, however, will not do, for ours must not only be very high but very steep, so that the station we choose at the bottom may be almost under the station we are afterward to occupy at the top.

Besides, we are not going to climb a lofty, lonely summit like tourists to spend an hour, but to spend weeks; so that we must have

fire and shelter, and above all we must have dry air to get clear skies. First I thought of the Peak of Teneriffe, but afterward some point in the Territories of the United States seemed preferable, particularly as the Government offered to give the expedition, through the Signal Service, and under the direction of its head, General Hazen, material help in transportation and a military escort, if needed, anywhere in its own dominions. No summit in the eastern part of the United States rises much over seven thousand feet; and, though the great Rocky Mountains reach double this, their tops are the home of fog and mist, so that the desired conditions, if met at all, could only be found on the other side of the continent in Southern California, where the summits of the Sierra Nevadas rise precipitously out of the dry air of the great wastes in lonely peaks, which look eastward down from a height of nearly fifteen thousand feet upon the desert lands.

This remote region was, at the time I speak of, almost unexplored, and its highest peak, Mount Whitney, had been but once or twice ascended, but was represented to be all we desired could we once climb it. As there was great doubt whether our apparatus, weighing several thousand pounds, could possibly be taken to the top, and we had to travel three thousand miles even to get where the chief difficulties would begin and make a desert journey of one hundred and fifty miles after leaving the cars, it may be asked why we committed ourselves to such an immense journey to face such unknown risks of failure. The answer must be that mountains of easy ascent and fifteen thousand feet high are not to be found at our doors, and that these risks were involved in the nature of our novel experiment, so that we started out from no love of mere adventure, but from necessity, much into the unknown. The liberality of a citizen of Pittsburg, to whose encouragement the enterprise was due, had furnished the costly and delicate apparatus for the expedition, and that of the transcontinental railroads enabled us to take this precious freight along in a private car, which carried a kitchen, a steward, a cook, and an ample larder besides.

In this we crossed the entire continent from ocean to ocean, stopped at San Francisco for the military escort, went three hundred miles south so as to get below the mountains, and then turned eastward again on to the desert, with the Sierras to the north of us, after a journey which would have been unalloyed pleasure except for the anticipation of what was coming as soon as we left our car. I do not indeed know that one feels the triumphs of civilization over the opposing forces of Nature anywhere more than by the sharp contrasts which the marvelous luxury of recent railroad accommodation gives to the life of the desert. When one is in the center of one of the great barren regions of the globe, and, after looking out from the windows of the flying train on its scorched wastes for lonely leagues of habitless desolation, turns to his well-furnished dinner-table, and the fruit and ices of his

dessert, he need not envy the heroes of Oriental story, who were carried across dreadful solitudes in a single night on the backs of flying genii. Ours brought us over three thousand miles to the Mohave Desert. It was growing hotter and hotter when the train stopped in the midst of vast sand wastes a little after midnight. Roused from our sleep, we stepped on to the brown sand, and saw our luxurious car roll away in the distance, experiencing a transition from the conditions of civilization to those almost of barbarism, as sharp as could well be imagined. We commenced our slow toil northward with a thermometer at 110° in the shade, if any shade there be in the shadeless desert, which seemed to be chiefly inhabited by rattlesnakes of an ashen-gray color, and a peculiarly venomous bite. There is no water save at the rarest intervals, and the soil at a distance seems as though strewed with sheets of salt, which aids the delusive show of the mirage. These are, in fact, the ancient beds of dried-up salt lakes or dead seas, some of them being below the level of the ocean; and such a one on our right, though only about twenty miles wide, has earned the name of "Death Valley," from the number of human beings who have perished in it. Formerly an emigrant train, when emigrants crossed the continent in caravans, had passed through the great Arizona deserts in safety until, after their half-year's journey, their eyes were gladdened by the snowy peaks of the Sierras looking delusively near. The goal of their long toil seemed before them; only this one more valley lay between, and into this they descended, thinking to cross it in a day—but they never crossed it. Afterward the long line of wagons was found with the skeletons of the animals in the harness, and by them those of men, women, and little children dead of thirst, and some relics of the tragedy remained at the time of our journey. I cite this as an indirect evidence of the phenomenal dryness of the region—a dryness which, so far, served our object, which was, in part, to get rid as much as possible of that water vapor which is so well known to be a powerful absorber of the solar heat.

Everything has an end, and so had that journey, which finally brought us to the goal of our long travel, at the foot of the highest peak of the Sierras, Mount Whitney, which rose above us in tremendous precipices, that looked hopelessly insurmountable and wonderfully near. The whole savage mountain-region, in its slow rises from the west and its descent to the desert plains in the east, is more like the chain called the Apennines, in the moon, than anything I know on the earth. The summits are jagged peaks like Alpine "needles," looking in the thin air so delusively near that, coming on such a scene unprepared, one would almost say they were large gray stones a few fields off, with an occasional little white patch on the top, that might be a handkerchief or a sheet of paper dropped there. But the telescope showed that the seeming stones were of the height of many Snowdons piled on one another, and the white patches occasional snow-fields, looking how

invitingly cool, from the torrid heat of the desert, where we were encamped by a little rivulet that ran down from some unseen ice-lake in that upper air. Here we pitched our tents and fell to work (for you remember we must have two stations, a low and a high one, to compare the results), and here we labored three weeks in almost intolerable heat, the instruments having to be constantly swept clear of the red desert dust which the hot wind brought. Close by these tents a thermometer covered by a single sheet of glass, and surrounded by wool, rose to 237° in the sun, and sometimes in the tent, which was darkened for the study of separate rays, the heat was absolutely beyond human endurance. Finally, our apparatus was taken apart and packed in small pieces on the backs of mules, who were to carry it by a ten days' journey through the mountains to the other side of the rocky wall which, though only ten or twelve miles distant, arose miles above our heads; and, leaving these mule-trains to go with the escort by this longer route, I started with a guide by a nearer way to those white gleams in the upper skies, that had daily tantalized us below in the desert with suggestions of delicious, unattainable cold. That desert sun had tanned our faces to a leather-like brown, and the change to the cooler air as we ascended was at first delightful. At an altitude of five thousand feet we came to a wretched band of nearly naked savages, crouched around their camp-fire, and at six thousand found the first scattered trees; and here the feeble suggestion of a path stopped, and we descended a ravine to the bed of a mountain-stream, up which we forced our way, cutting through the fallen trees with an axe, fighting for every foot of advance, and finally passing what seemed impassable. It was interesting to speculate as to the fate of our siderostat mirrors and other precious freight, now somewhere on a similar road, but quite useless. We were committed now, and had to make the best of it—and, besides, I had begun to have my attention directed to a more personal subject. This was that the colder it grew the more the sun burned the skin—quite literally burned I may say, so that by the end of the third day my face and hands, case-hardened, as I thought, in the desert, began to look as if they had been seared with red-hot irons, here in the cold where the thermometer had fallen to freezing at night; and still as we ascended the paradoxical effect increased; the colder it grew about us, the hotter the sun blazed above.

We have all heard probably of this curious effect of burning in the midst of cold, and some of us may have experienced it in the Alps, where it may be aided by reflection from the snow, which we did not have about us at any time except in scattered patches, but here by the end of the fourth day my face was scarcely recognizable, and it almost seemed as though sunbeams up here were different things, and contained something which the air filters out before they reach us in our customary abodes. Radiation here is increased by the absence of water vapor too, and on the whole this intimate personal experience

fell in almost too well with our anticipations that the air is an even more elaborate trap to catch the sunbeams than had been surmised, and that this effect of selective absorption and radiation was intimately connected with that change of the primal energies and primal color of the sun which we had climbed toward it to study.

On the fourth day, after break-neck ascents and descents, we finally ascended by a ravine, down which leaped a cataract, till, at nightfall, we reached our upper camp, which was pitched by a little lake, one of the sources of the waterfall, at a height of about twelve thousand feet, but where we seemed in the bottom of a valley, nearly surrounded as we were by an amphitheatre of rocky walls which rose perpendicularly to the height of Gibraltar from the sea, and cut off all view of the desert below or even of the peak above us.

The air was wonderfully clear, so that the sun set in a yellow rather than an orange sky, which was reflected in the little ice-rimmed lakes and from occasional snow-fields on the distant waste of lonely mountain-summits on the west.

The mule-train sent off before by another route had not arrived when we got to the mountain-camp, and we realized that we were far from the appliances of civilization by our inability to learn about our chief apparatus, for here, without post or telegraph, we were as completely cut off from all knowledge of what might be going on with it in the next mountain ravine as a ship at sea is of the fate of a vessel that sailed before from the same port. During the enforced idleness we ascended the peak nearly three thousand feet above us, with our lighter apparatus, leaving the question of the ultimate use of the heavy ones to be settled later. There seemed little prospect of carrying it up, as we climbed where the granite walls had been split by the earthquakes, letting a stream of great rocks, like a stone river, flow down through the interstices by which we ascended, and, in fact, the heavier apparatus was not carried above the mountain-camp.

The view from the very summit was over numberless peaks on the west to an horizon fifty miles away, of unknown mountain-tops, for, with the exception of the vast ridge of Mount Tyndall, and one or two less conspicuous ones, these summits are not known to fame, and, wonderful as the view may be, all the charm of association with human interest which we find in the mountain landscape of older lands is here lacking.

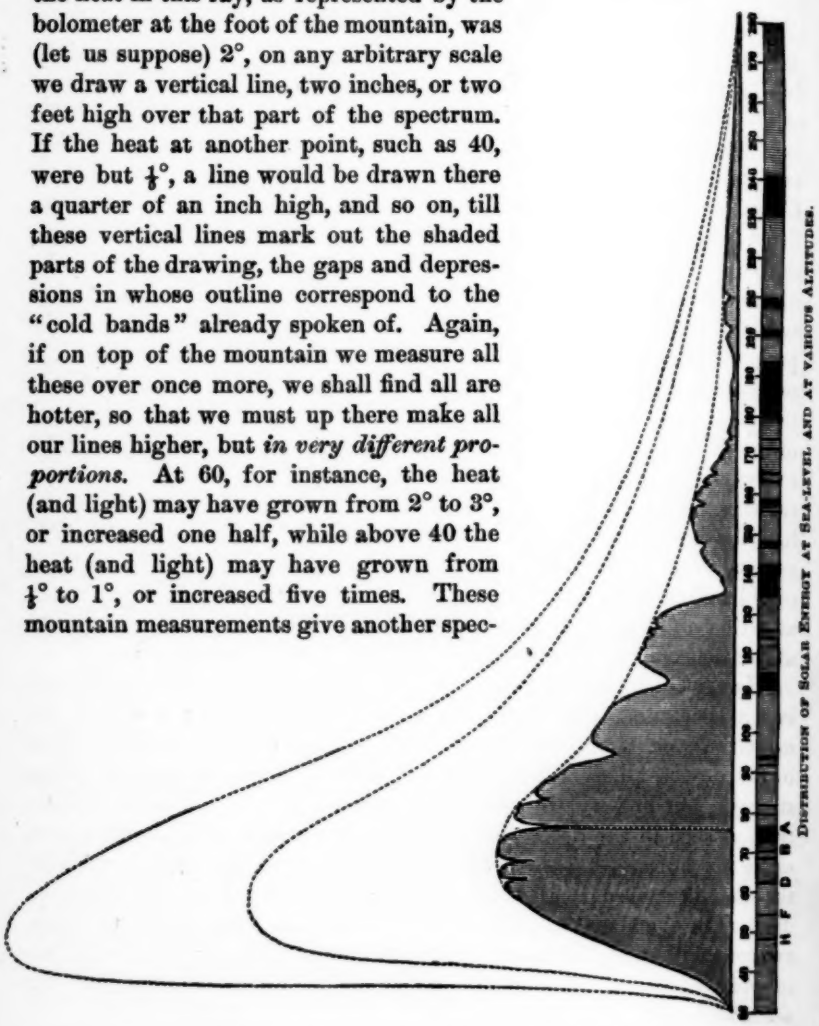
It was impossible not to be impressed with the savage solitude of this desert of the upper air, and our remoteness from man and his works, but I turned to the study of the special things connected with my mission. Down far below the air seemed filled with reddish dust that looked like an ocean. This dust is really present everywhere (I have found it in the clear air of Etna), and, though we do not realize its presence in looking up through it, to one who looks down on it the dwellers on the earth seem indeed like creatures at the bottom of a

troubled ocean. We had certainly risen toward the surface, for about us the air was of exquisite purity, and above us the sky was of such a deep violet blue as I have never seen in Egypt or Sicily, and yet even this was not absolutely pure, for, separately invisible, the existence of fine particles could yet be inferred from their action on the light near the sun's edge, so that even here we had not got absolutely above that dust-shell which seems to encircle our whole planet. But we certainly felt ourselves not only in an upper, but a different region. We were on the ridge of the continent, and the winds which tore by had little in common with the air below, and were bearing past us (according to the geologists) dust which had once formed part of the soil of China, and been carried across the Pacific Ocean; for here we were lifted into the great encircling currents of the globe, and, "near to the sun in lonely lands," were in the right conditions to study the differences between his rays at the surface and at the bottom of that turbid sea where we had left the rest of mankind. We descended the peak and hailed with joy the first arrival of our mule-trains with the requisite apparatus at the mountain-camp, and found that it had suffered less than might be expected, considering the pathless character of the wilderness. We went to work to build piers and mount telescopes and siderostats, in the scene shown by the next illustration on the screen, taken from a sketch of my own, where these rocks in the immediate foreground rise to thrice the height of St. Paul's. We suffered from cold (the ice forming three inches deep in the tents at night) and from mountain-sickness, but we were too busy to pay much attention to bodily comfort, and worked with desperate energy to utilize the remaining autumn days, which were all too short.

Here, as below, the sunlight entered a darkened tent, and was spread into a spectrum, which was explored throughout by the bolometer, measuring, on the same separate rays which we had studied below in the desert, all of which were different up here, all having grown stronger, but in very different proportions. On the screen is the spectrum as seen in the desert, drawn on a conventional scale, neither prismatic nor normal, but such that the intensity of the energy shall be the same in each part, as it is represented here by these equal perpendiculars in every color. Fix your attention on these three as types, and you will see better what we found on the mountain, and what we inferred as to the state of things still higher up, at the surface of the aërial sea.

You will obtain, perhaps, a clearer idea, however, from the following statement, where I use, not the exact figures used in calculation, but round numbers, to illustrate the process employed. I may premise that the visible spectrum extends from H (in the extreme blue) to A (in the deepest red), or from near 40 (the ray of $\frac{40}{100,000}$ of a millimetre in wave-length) to near 80. All below 80, to the right, is the invisible infra-red spectrum.

Now, the shaded curve above the spectrum represents the amount of energy in the sun's rays at the foot of the mountain, and was obtained in this way: Fix your attention for a moment on any single part of the spectrum, for instance, that whose wave-length is 60. If the heat in this ray, as represented by the bolometer at the foot of the mountain, was (let us suppose) 2°, on any arbitrary scale we draw a vertical line, two inches, or two feet high over that part of the spectrum. If the heat at another point, such as 40, were but ⅛°, a line would be drawn there a quarter of an inch high, and so on, till these vertical lines mark out the shaded parts of the drawing, the gaps and depressions in whose outline correspond to the "cold bands" already spoken of. Again, if on top of the mountain we measure all these over once more, we shall find all are hotter, so that we must up there make all our lines higher, but *in very different proportions.* At 60, for instance, the heat (and light) may have grown from 2° to 3°, or increased one half, while above 40 the heat (and light) may have grown from ⅛° to 1°, or increased five times. These mountain measurements give another spectrum, the energies in each part of which are defined by the middle dotted line, which we see indicates very much greater energy whether heat or light in the blue end than below. Next, the light or heat which would be observed at the surface of the atmosphere is found in this way. If the mountain-top rises through one half the absorbing mass of this terrestrial atmosphere (it does not quite do so, in fact), and, by getting rid of that lower half, the ray 60 has grown in bright-



Distribution of Solar Energy at Sea-level and at various Altitudes.

ness from two to three, or half as much again, in going up to the top it would gain half as much more, or become 4½, while the ray near 40, which has already increased to five times what it was, would increase five times more, or to 25. Each separate ray increasing thus nearly in some geocentric progression (though the heat, as a whole, does not), you see how we are able, by repeating this process at every point, to build up our outer or highest curve, which represents the light and heat at the surface of the atmosphere. These have grown out of all proportion at the blue end, as you see by the outer dotted curve, and now we have attained, by actual measurement, that evidence which we sought, and by thus reproducing the spectrum outside the atmosphere, and then recombining the colors by like methods to those you have seen on the screen, we finally get the true color of the sun, which tends, broadly speaking, to blue.

It is so seldom that the physical investigator meets any novel fact quite unawares, or finds anything except that in the field where he is seeking, that he must count it an unusual experience to come unexpectedly on even the smallest discovery. This experience I had on one of the last days of work on the spectrum on the mountain. I was engaged in exploring that great invisible heat-region, still but so partially known, or, rather, I was mapping in that great "dark continent" of the spectrum, and by the aid of the exquisite sky and the new instrument (the bolometer) found I could carry the survey further than any had been before. I substituted the prism for the grating, and measured on in that unknown region till I had passed the *ultima Thule* of previous travelers, and finally came to what seemed the very end of the invisible heat-spectrum beyond what had previously been known. This was in itself a return for much trouble, and I was about rising from my task, when it occurred to me to advance the bolometer still farther, and I shall not forget the surprise and emotion with which I found new and yet unrecognized regions below—a new invisible spectrum beyond the farthest limits of the old one.

I will anticipate here by saying that after we got down to lower earth again the explorations and mapping of this new region were continued. The amount of solar energy included in this new extension of the invisible region is much less than that of the visible spectrum, while its length upon the wave-length scale is equal to all that previously known, visible and invisible, as you will see better by this view, having the same thing on the normal as well as the prismatic scale. If it be asked which of these is correct, the answer is, "Both of them." Both rightly interpreted mean just the same thing, but in the lower one we can more conveniently compare the ground of the researches of others with these. These great gaps I was at first in doubt about, but more recent researches at Allegheny make it probable that they are caused by absorption in our own atmosphere, and not in that of the sun.

We would gladly have stayed longer, in spite of physical discom-

fort, but the formidable descent and the ensuing desert journey were before us, and certainly the reign of perpetual winter around us grew as hard to bear as the heats of the desert summer had been. On September 10th we sent our instruments and the escort back by the former route, and, ourselves unencumbered, started on the adventurous descent of the eastern precipices by a downward climb, which, if successful, would carry us to the plains in a single day. I at least shall never forget that day, nor the scenery of more than Alpine grandeur which we passed in our descent, after first climbing by frozen lakes in the northern shadow of the great peak, till we crossed the eastern ridges, through a door so narrow that only one could pass it at a time, by clinging with hands and feet as he swung round the shoulder of the rocks—to find that he had passed in a single minute from the view of winter to summer, the prospect of the snowy peaks behind shut out, and instantly exchanged for that below of the glowing valley and the little oasis where the tents of the lower camp were still pitched, the tents themselves invisible, but the oasis looking like a green scarf dropped on the broad floor of the desert. We climbed still downward by scenery unique in my recollection. This view of the ravine on the screen is little more than a memorandum made by one of the party in a few minutes' halt part-way down, as we followed the ice-stream between the tremendous walls of the defile which rose two thousand feet, and between which we still descended, till, toward night, the ice-brook had grown into a mountain-torrent, and, looking up the long vista of our day's descent, we saw it terminated by the Peak of Whitney, once more lonely in the fading light of the upper sky.

This site, in some respects unequaled for a physical observatory, is likely, I am glad to say, to be utilized, the President of the United States having, on the proper representation of its value to science, ordered the reservation for such purposes of an area of one hundred square miles about and inclusive of Mount Whitney.

There is little more to add about the journey back to civilization, where we began to gather the results of our observation, and to reduce them—to smelt, so to speak, the metal from the ore we had brought home—a slow but necessary process, which has occupied a large part of two years.

The results stated in the broadest way mean that the sun is blue—but mean a great deal more than that; this blueness in itself being perhaps a curious fact only, but, in what it implies, of practical moment.

We deduce in connection with it a new value of the solar heat, so far altering the old estimates that we now find it capable of melting a shell of ice sixty yards thick annually over the whole earth, or, what may seem more intelligible on its practical bearings, of exerting over one horse-power for each square yard of the normally exposed surface. We have studied the distribution of this heat in a spectrum whose limits on the normal scale our explorations have carried to an extent

of rather more than twice what was previously known, and we have found that the total loss by absorption from atmosphere is nearly double what it has been heretofore supposed.

We have found it probable that the human race owes its existence and preservation even more to the heat-storing action of the atmosphere than has been believed.

The direct determination of the effect of water-vapor in this did not come within our scope; but that the importance of the blanketing action of our atmospheric constituents has been in no way overstated may be inferred when I add that we have found by our experiments that, if the planet were allowed to radiate freely into space without any protecting veil, its sunlit surface would probably fall, even in the tropics, below the temperature of freezing mercury.

I will not go on enumerating the results of these investigations, but they all flow from the fact, which they in turn confirm, that this apparently limpid sea above our head, and about us, is carrying on a wonderfully intricate work on the sunbeam, and on the heat returned from the soil, picking out selected parts in hundreds of places, sorting out incessantly at a task which would keep the sorting demons of Maxwell busy, and, as one result, changing the sunbeam on its way down to us in the way we have seen.

I have alluded to the practical utilities of these researches, but, practical or not, I hope we may feel that such facts as we have been considering about sunlight and the earth's atmosphere may be stones useful in the future edifice of science, and that if not in our own hands then in those of others, when our day is over, they may find the best justification for the trouble of their search, in the fact that they prove of some use to man.

May I add an expression of my personal gratification in the opportunity with which you have honored me of bringing these researches before the Royal Institution, and of my thanks for the kindness with which you have associated yourselves for an hour, in retrospect at least, with that climb toward the stars which we have made together, to find, from light in its fullness, what unsuspected agencies are at work to produce for us the light of common day?

THE SCIENCE OF MORALITY.

By SELIM M. FRANKLIN.

BY morals, or the science of morality, is meant that body of principles and laws, relating to conduct, which are conducive to the well-being of humanity. Morality, or, more accurately, the art of morality, is the carrying out in practice the laws which the science has established.

To understand clearly the definition of the science, it is necessary to ascertain what the well-being of humanity is. This can be done only by tracing all motives and feelings to their ultimate cause. This ultimate cause is the most powerful instinct implanted in human nature—the preservation of life, which includes our own life and that of our offspring. We live and we want to live. Unconsciously we will flee from danger. We will fight frantically against death. In the presence of great danger we lose our reason, and yet, though volition is powerless, reflex action makes us struggle for safety. Why we want to live, why we were ever endowed with life, is more than man can know; but of this he is certain, that he does not want to die. The fact that a mother will sacrifice herself for her child; that the man who suffers the tortures of the rack, or of incurable disease, or of great mental affliction, will prefer oblivion to existence, does not alter the truth that the love of life is the most powerful instinct implanted in animals and in man. These exceptions, like many apparent exceptions to the law of gravitation, can be satisfactorily explained away.

By the phrase "conducive to the well-being of humanity" is meant not merely the bare preservation of life, but includes all that which makes life itself more pleasant and happy, which will insure a more complete and rounded existence.

All those actions which are conducive to the well-being of humanity, we call good or right; all those actions which are not so conducive, we call bad or wrong. Thus there is an absolute standard of right and wrong.

Already, long ages ago, it was discovered by experience that a tribe or nation, and every member thereof, would better serve his own prosperity and success by generally telling the truth than by telling falsehoods; so nine times out of ten he would tell the truth. The confusion that would arise were every one to tell nine falsehoods to one truth is inconceivable. The man who had been placed on sentinel duty, when asked whether he had seen the enemy, would answer no, although he knew the enemy to be within the hearing of his voice. The mother would tell her child that certain herbs, which she knew to be poisonous, were good to eat; the child would eat, and die. The father would deny his ability to provide food for his family, although but an hour before he had slain a buffalo or a deer. Telling the truth sometimes, and most of the time, is an absolute necessity, depending not on theological injunctions, but on the very existence of life. Our rude forefathers of the prehistoric age were aware of this fact, and they enunciated the general principle that it is wrong to lie. This is a scientific generalization. It is a law deduced by experience and observation from a great number of facts, and it is as justly entitled to be considered a generalization as Newton's law of gravitation or Pascal's principle of hydrostatics. The experience of nations and of ages

has firmly established this principle; it is incorporated into all codes of morals.

In the physical sciences we explain any particular phenomenon by laws already established. We explain the reason why any particular candle burns and gives off light, by laws already discovered of oxidation and incandescence. So in the science of morality we determine whether any particular action is right or wrong, by referring the action under consideration to laws that have eebn already established.

Certain laws conduce more to the well-being of humanity than others. Thus, the law, It is wrong to murder, is of vastly more importance than the law, It is wrong to lie. Because, if we all committed murder, the world would be depopulated; while, if we all told lies, there would be a sad confusion, yet some of us would manage to exist. Hence, to commit murder is a greater wrong than to tell a lie, and a man would be perfectly justified in telling a lie in order to escape either becoming a murderer or being himself murdered. In this manner we can test the relative importance of moral laws.

As the attraction of gravitation differs under different circumstances, although the law of gravitation always remains the same, so can a falsehood, according to circumstances, be a greater or lesser wrong—be a so-called white lie of society, be the business lie of the dishonest tradesman, or the criminal lie of the perjurer—and still the law, It is wrong to lie, would remain unassailed. We determine by deduction whether any particular action is right or wrong: If the act is in conflict with a law of morality, it is wrong; if not in conflict, it is right.

The laws of morality are not all of the same relative importance. Those laws which are more vital to the well-being of humanity are more important than those laws which are less vital. Hence, occasions can arise when we are justified in breaking one law, in order that we may escape breaking another of greater importance.

The thinking mind of to-day asks, Is there a scientific basis for morality? I think there is. The modified doctrine of utility, or, as I have expressed it, conducive to the well-being of humanity, is the basis which science seeks. We deduce, from the experience of races and nations for centuries and for ages, the laws in regard to conduct which are for man's best welfare. These laws, systematically arranged, would constitute the science of morality or morals. As yet such a science does not exist. The material is all at hand; it but awaits the master-workman to fashion it into shape.

An incidental question here arises. Had we a most complete science of morality, would it affect, either for better or for worse, the morality of the masses? At present the dictates of morality are enforced in three ways: By the so-called criminal or penal laws of the land; by public opinion, or the opinion of society; by the teachings of

punishment after death. These three sanctions must always exist. The science of morality might not have any effect in compelling its laws to be observed, but it undoubtedly would explain to many minds which now are groping in darkness and disbelief the why and wherefore of moral codes.

RECENT PROGRESS IN BIOLOGY.

By E. RAY LANKESTER.

THE English universities have at various times in their history been remarkable as centers of scientific investigation and progress. The Royal Society took its origin in Oxford about two hundred and forty years ago, and from time to time there have been brilliant groups of scientific investigators in either university who have, though separated by intervals of darkness, sufficed to maintain the character of these institutions as something more than schools of classical training or mathematical gymnastic. At the present moment the energy of the Biological school, which has grown up in Cambridge within the last fifteen years, forms one of the most remarkable features among the many recent evidences of healthy life and of capacity for the performance of its great national duties which that time-honored institution has afforded.

One of the most fascinating problems of biology is that involved in the attempt to trace out the pedigrees of the immense variety of living plants and animals according to the teachings of Charles Darwin. Every animal grows from a perfectly simple homogeneous egg to the more or less complicated form which it presents when adult, and we have reason to believe that the changes through which the growing developing "embryo" passes correspond to a large extent, according to certain definite laws, with the changes through which its ancestors have passed in the greater evolution of the world. Accordingly, these embryonic changes, if rightly understood, can furnish us with the most important evidence as to the ancestry, and therewith the pedigree and family relationships, of the various kinds of existing animals. The study of embryology, from this point of view, was followed with great success by the late Professor Frank Balfour (whose early death has caused incalculable loss to science), and is being prosecuted in Germany and America, but nowhere more energetically than by Balfour's pupils. It will be readily understood that if the history of growth from the egg can furnish a clew to the ancestral relationships of various animals, then the discovery of this history in the case of curious and abnormal animals must be especially important. The histories of whole groups of common animals will necessarily be very much alike, and there is no likelihood of one differing from another in

essential respects. Thus the facts with regard to the growth of birds from the egg are, in regard to large features, the same which have been carefully ascertained with regard to the common fowl. The growth from the egg of ordinary hairy quadrupeds presents the same characters as that of the rabbit, the dog, and man. The history of the changes of the eggs of fish on their way from simple homogeneity to the rich complexity of adult life is practically the same for all fish truly so called; and so we may say of insects—that one insect furnishes the history which is true of all. This, be it remembered, relates only to large and general features. But naturalists are acquainted with a number of strangely abnormal animals which will not enter into large groups and even defy classification, being neither "flesh, fowl, nor good red herring." These recalcitrant animals are not objectionable to the zoölogist; on the contrary, they are his favorites. It is these which he is most eager to study, and it is from them that he expects to obtain information which will clear up doubtful points in the scheme of relationships or pedigree which he has provisionally constructed on the basis of his acquaintance with less isolated forms. These exceptional forms of animal life are found in various parts of the world, and are often difficult of access. Nevertheless, if the naturalist is to study the growth from the egg of these animals, he must follow them to their native homes. Botanists have a great advantage over zoölogists in the fact that most plants are readily transported from one locality to another, and can be cultivated in artificial climates produced in glass houses. We have at present no such skill in the treatment of animals, and accordingly the energetic Cambridge naturalists have risen to the necessities of the case. Within the last three years special journeys have been undertaken from Cambridge by members of its biological school to the uttermost parts of the earth, with the sole purpose of studying the growth from the egg of strange and interesting animals, only to be obtained in the remote regions thus visited. Mr. Caldwell, Fellow of Caius College, has gone to Australia, and is still there, for the purpose of studying the history of the growth from the egg of the duck-billed Platypus or duck-mole (*Ornithorhynchus*) and the spiny ant-eater (*Echidna*), as well as of the extraordinary lung-bearing, and therefore air-breathing, fish of Queensland known as the Barra-munda (*Ceratodus Forsteri*). Mr. Adam Sedgwick, Fellow of Trinity College, went in 1883 to the Cape of Good Hope expressly for the purpose of collecting live specimens and, if possible, eggs and young, of a creature very much like a caterpillar in appearance, and known as *Peripatus*. He obtained the most complete success, brought home to England three hundred living specimens of the extraordinary *Peripatus*, and has obtained from them since they have been in England young in all stages of development, which will enable him very soon to give a most valuable account of the growth from the egg of this strange form. A third member of the

Cambridge school—Mr. William Bateson, of Pembroke College—has been twice across the Atlantic, in 1883 and 1884, to the coast of Maryland, U. S. A., in order to study the growth from the egg of *Balanoglossus*, the most important and (to the zoölogist) entertaining of all worms, since it has gill-slits like a fish and rudiments of a backbone. Mr. Bateson has made and already published (in a special supplement of the "Quarterly Journal of Microscopical Science," 1885) a complete study of the development of this worm. It is perhaps as well briefly to mention here that a "complete study" in these questions means the preparation and preservation in alcohol of hundreds of specimens of different stages of growth (often very minute) of the animal under investigation, and the subsequent cutting into series of consecutive slices, each about $\frac{1}{1000}$ of an inch thick, of a sample of each of these stages; the scrutiny of these sections with the microscope, and the reconstruction or building up of the actual structure of the animal at each stage by a mental combination of the sections.

The expedition undertaken by Mr. Caldwell (who was aided in his equipment by funds from the Government Grant Committee of the Royal Society) is perhaps the most interesting, because the animals which he has gone to study are of large size and already more or less familiar. The Ornithorhynchus and the Echidna are hairy quadrupeds (mammals) peculiar to Australasia, which differ from all other hairy quadrupeds in having, like birds, but a single aperture to the exterior for the intestine and the urino-genital canals, and in having the skeleton of the shoulder-girdle and some other features of structure similar to those of reptiles. Like those of reptiles, their bodies are comparatively cold, instead of being kept to a definite "blood-heat" (100° Fahr.) as are those of all other mammals. It had often been reported, and some kind of evidence had been given to support the statement, that these strange beasts lay their eggs like birds and reptiles, instead of retaining the egg-like structure within the body and allowing it there to develop to a certain condition of maturity as do all other hairy quadrupeds. One of Mr. Caldwell's objects was definitely to ascertain whether these animals lay eggs or not, and, of more importance than that, to examine minutely the whole history of the growth in the egg, and to compare it on the one hand with the corresponding development of birds and reptiles, on the other with that of ordinary hairy quadrupeds or mammals.

Mr. Caldwell has found out all about the eggs of these animals and collected them in quantities. The Echidna lays a single egg, which she then carries about with her in a pouch formed by a fold of skin on the ventral surface of the body, similar to the kangaroo's pouch.

The duck-mole, on the other hand, lays two eggs at a time and does not carry them about, but deposits them in her nest, an underground burrow like that of the mole. Naturalists are awaiting with

great interest Mr. Caldwell's account of what goes on inside these eggs while the young one is growing there; that is to say, an account of the differences and resemblances between the structures which gradually arise in these mammals' eggs and those which are familiar to us as occurring in the case of the common fowl.

With regard to the strange fish, *Ceratodus*, Mr. Caldwell has been no less successful, after much disappointment and persevering search. He has lately sent home a series of photographs showing groups of the black men and women whom he employed to catch the fish, standing by the river-side and holding each one in his arms a newly captured specimen, while some twenty or thirty more of the fish are heaped on the ground. Four years ago, zoölogists were glad to buy spirit-preserved specimens of this fish in London for twenty pounds apiece. Mr. Caldwell has as yet sent home so few reports of his doings in Australia, that every one will be interested in the following letter written from New South Wales in February last:

I shall give you a short account of my doings without apologizing for talking about myself, because you asked for this. When I wrote you last I was just beginning my camp-life on the Burnett River, and was very much concerned about my failure in the search for Ceratodus-eggs. I had invested in an American trap and horses and all the necessaries for camping out. I remained under canvas from the end of July to the end of November. Roget, my Belgian servant, was the only white man with me, but the blacks kept continually coming and adding to the number of my retainers. I had in the end about fifty of all ages—men, women, and children. I have sent you some photographs which I took during these months. I carried my camera everywhere, and the pictures will give you a fine idea of bush scenery and the roads (?) we had to traverse. I became very expert with my four-in-hand. It is a very different thing from driving a team along good roads; but I was fortunate in never having a serious smash. The blacks were more than useful: I could have done little or nothing without them. They found over five hundred Echidna in four weeks, while the "gins" searched the weeds of the river for Ceratodus-eggs. Let me tell you how I found Ceratodus-spawn. From the 24th of April (1884), when I found males ready to spawn, I had a pair, male and female, under constant observation in a small water-hole. Up to the beginning of September, though I was constantly dredging and turning up the river, I got no clew to the spawning-ground. I determined to give up the search for the year, as further stay on the Burnett interfered with my plans for collecting the eggs of the duck-mole. All August I had been getting the eggs of the duck-mole, containing very early stages of the young; but with September the eggs had all been laid, and my plan was to shift my camp south to the colder district of New England, where, as I found in 1883, the duck-mole is a month or six weeks later in breeding. One evening early in September I was shooting duck-moles as usual, when I came to a place on the bank of the river where I could see several Ceratodus swimming about backward and forward in shallow water. It was too dark to look for anything that night, so I marked the place and described to the blacks what I expected. They were down at the river by daylight, and shortly afterward returned with Ceratodus-eggs. The egg is like that of a newt, and is laid in the water-weed, every egg separately. This changed my plans. I hoped

then to get all stages in the growth of Ceratodus in a few weeks, and to try for the duck-moles again in December about the Snowy River in the extreme south of New South Wales. But it was not until the end of November that I got away. I could not succeed for a long time in rearing the larvæ (tadpoles) of the Ceratodus after they were hatched. At last I succeeded, and have now I believe every stage preserved. I have now in my laboratory in Sydney some young living specimens reared from the eggs under my eyes.

Is it not extraordinary that Echidna has not learned to contain her egg in the uterus a little longer? The plan of laying it only to carry it in a pouch is an awkward habit that might be so easily reformed. The duck-mole has two eggs at a time. The papers here have copied from "Nature" a notice about my work, and mention an old paper by Geoffroy St.-Hilaire where Platypus (duck-mole) eggs are figured. These eggs, however, happen not to be duck-mole's eggs at all. St.-Hilaire obtained them from bushmen who found them in the Hawkesbury River. They were eggs of the common river-turtle, as is clear from the figures. The duck-mole's egg is one quarter of their size. . . . I am at present in the northwestern district of New South Wales—up the McIntyre River—collecting the embryos of marsupials (kangaroos, etc.). I have bought a light buggy, and move about from station to station in search of kangaroo-drives. The kangaroos have decreased in number, owing to the drought in the last few years, and the place I am in now is, I believe, almost the only one where it is still possible to get a thousand kangaroos into a "yard" in one day. "Yarding" has been generally superseded by shooting. A camp of kangaroo-shooters will travel about on a run for months, being paid so much a scalp. It is very slow work collecting embryos with these shooting-parties, and, besides this, the embryos are too delicate to be carried on horseback. Accordingly, I have tried hard to get to a yarding-drive where I could put up a table and do all the preserving in one place. On Tuesday, Wednesday, and Thursday next week the whole district is going to muster to drive kangaroos into a pit, and we hope to get five thousand. My plans after this are pretty well settled. I have made up my mind to stay out until another season is over. I go after "native cats" in March and April, opossums in April and May in the south of New South Wales. In June I shall get emu on the western downs of Queensland, two hundred miles west of Roma. In July and August I shall have a camp of one or two hundred blacks on the Burnett River. At the end of August and September I shall camp with some white shooters on the rivers near where I am now (the Dumeresq, McIntyre, Mole, and Severn). In November I shall see you in London. I shall send you a description of some of the important features in the early growth of the young in the egg of the duck-mole and the Echidna when I get down to Sydney. I shall have no time to make sections until I have brought my material safely home to England.—*Nineteenth Century.*

THE PRIMITIVE GHOST AND HIS RELATIONS.

By JAMES G. FRAZER.

IN his "Roman Questions," that delightful storehouse of old-world lore, Plutarch asks, "When a man who has been falsely reported to have died abroad returns home alive, why is he not admitted by the door, but gets up on the tiles, and so lets himself down into the

house?" The curious custom to which Plutarch here refers prevails in modern Persia, for we read in "Hajji Baba" (c. 18) of the man who went through "the ceremony of making his entrance over the roof, instead of through the door; for such is the custom, when a man who has been thought dead returns home alive." From a passage in Agathias (ii, 23) we may, perhaps, infer that the custom in Persia is at least as old as the sixth century of our era. A custom so remote from our modern ways must necessarily have its roots far back in the history of our race. Imagine a modern Englishman, whom his friends had given up for dead, rejoining the home circle by coming down the chimney instead of entering by the front door! In this paper I propose to show that the custom originated in certain primitive beliefs and observances touching the dead—beliefs and observances by no means confined to Greece and Rome, but occurring in similar if not identical forms in many parts of the world.

The importance attached by the Romans in common with most other nations to the due performance of burial rites is well known, and need not be insisted on. For the sake of my argument, however, it is necessary to point out that the attentions bestowed on the dead sprang not so much from the affections as from the fears of the survivors. For, as every one knows, ghosts of the unburied dead haunt the earth and make themselves exceedingly disagreeable, especially to their undutiful relatives. Instances would be superfluous; it is the way of ghosts all the world over, from Brittany to Samoa.* But burial by itself was by no means a sufficient safeguard against the return of the ghost; many other precautions were taken by primitive man for the purpose of excluding or barring the importunate dead. Some of these precautions I will now enumerate. They exhibit an ingenuity and fertility of resource worthy of a better cause.

In the first place, an appeal was made to the better feelings of the ghost. He was requested to go quietly to the grave, and at the grave he was requested to stay there.†

But to meet the possible case of hardened ghosts, upon whom moral persuasion would be thrown away, more energetic measures were resorted to. Thus among the South Slavonians and Bohemians, the bereaved family, returning from the grave, pelted the ghost of their deceased relative with sticks, stones, and hot coals.‡ The Tschuwasche, a tribe in Finland, had not even the decency to wait till he was fairly in the grave, but opened fire on him as soon as the coffin was outside the house.*

Again, heavy stones were piled on his grave to keep him down, on

* Sebillot, "Traditions et Superstitions de la Haute-Bretagne," i, p. 238; Turner, "Nineteen Years in Polynesia," p. 233.

† Gray, "China," i, pp. 300, 304.

‡ Ralston, "Songs of the Russian People," p. 319; Bastian, "Mensch," ii, p. 329.

* Castren, "Finnische Mythologie," p. 120.

the principle of "sit tibi terra *gravis*." This is the origin of funeral cairns and tombstones. As the ghosts of murderers and their victims are especially restless, every one who passes their graves in Arabia, in Germany, and in Spain, is bound to add a stone to the pile. In Oldenburg (and no doubt elsewhere) if the grave is shallow the ghost will certainly walk.*

One of the most striking ways of keeping down the dead man is to divert the course of a river, bury him in its bed, and then allow the river to resume its course. It was thus that Alaric was buried, and Commander Cameron found the same mode of burial still in vogue for chieftains among a tribe in Central Africa.†

The expedient of inclosing the grave with a fence too high for the ghost to "take" it, especially without a run, is common to Finland and the South Seas.‡

Another simple but effectual plan was to nail the dead man to the coffin (the Tschuwasche again),# or to tie his feet together (among the Arabs), or his neck to his legs (among the Troglodytes, Damaras, and New-Zealanders).‖ The Wallachians drive a long nail through the skull and lay the thorny stem of a wild rose-bush on the corpse.△ The Californians clinched matters by breaking his spine.◊ The corpses of suicides and vampires had stakes run through them.‡

Other mutilations of the dead were intended not so much to keep the dead man in his grave as to render his ghost harmless. Thus the Australians cut off the right thumb of a slain enemy, that his ghost might not be able to draw the bow,‡ and Greek murderers used to hack off the extremities of their victims with a similar object.‡

Again, various steps were taken to chase away the lingering ghost from the home he loved too well. Thus the New-Zealanders thrash the corpse in order to hasten the departure of the soul;** the Algonquins†† beat the walls of the death-chamber with sticks to drive out the ghost; the Chinese knock on the floor with a hammer;‡‡ and the Ger-

* Sonntag, "Todtenbestattung," p. 197; Brand's "Popular Antiquities," ii, p. 309; Wuttke, "Deutsche Aberglaube," § 754, cp. 739, 748, 756, 758, 761; Klemm, "Culturgeschichte," ii, p. 225; Waitz, "Anthropologie der Naturvölker," ii, pp. 195, 324, 325, 524; Id., iii, p. 202.

† "Across Africa," i, p. 110.

‡ Castren, *op. cit.*, 121; Bastian, ii, p. 368.

\# Bastian, ii, pp. 337, 365.

‖ Strabo, xvi, 17; Diodorus, iii, 33; Wood, "Natural History of Man," i, p. 348; Yates, "New Zealand," p. 136.

△ H. F. Tozer, "Researches in the Highlands of Turkey," ii, p. 92.

◊ Bastian, ii, p. 331.

‡ Bastian, ii, p. 365; Ralston, p. 413; heads of vampires cut off (Wuttke, § 765; Toppen, "Aberglauben aus Masuren," p. 114; Tettau u. Temme, "Volkssagen," p. 275).

‡ Tylor, "Primitive Culture," i, p. 451.

‡ Suidas, *s.* μασχαλισθῆναι, μασχαλίσματα.

** Klemm, iv, p. 325; Yates, "New Zealand," p. 136.

†† Brinton, "Myths of the New World," p. 255. ‡‡ Gray, "China," i, p. 280.

mans wave towels about, or sweep the ghost out with a besom,* just as in old Rome the heir solemnly swept out the ghost of his predecessor with a broom made specially for the purpose.† In ancient Mexico professional "chuckers-out" were employed, who searched the house diligently till they found the lurking ghost of the late proprietor, whom they there and then summarily ejected.‡

The favorite "beat" of the ghost is usually the spot where he died. Hence, in order to keep him at least from the house, the Caffres carry a sick man out into the open air to die, and the Maoris used to remove the sick into sheds. If a Caffre or Maori died before he could be carried out, the house was tabooed and deserted.* There are traces in Greece, Rome, and China of this custom of carrying dying persons into the open air.‖

But in case the ghost should, despite all precautions, make his way back from the grave, steps were taken to barricade the house against him. Thus, in some parts of Russia and East Prussia an axe or a lock is laid on the threshold, or a knife is hung over the door,△ and in Germany as soon as the coffin is carried out of the house all the doors and windows are shut, whereas, so long as the body is still in the house, the windows (and sometimes the doors) are left constantly open to allow the soul to escape.◊ In some parts of England every bolt and lock in the house is unfastened, that the ghost of the dying man may fly freely away.‡

But, if primitive man knew how to bully, he also knew how to outwit the ghost. For example, a ghost can only find his way back to the house by the way by which he left it. This little weakness did not escape the vigilance of our ancestors, and they took their measures accordingly. The coffin was carried out of the house, not by the door, but by a hole made for the purpose in the wall, and this hole was carefully stopped up as soon as the body had been passed through it; so that, when the ghost strolled quietly back from the grave, he found to his surprise that there was no thoroughfare. The credit of this ingenious device is shared equally by Greenlanders, Hottentots,

* Wuttke, §§ 725, 737; F. Schmidt, Sitten u. Gebraüche in Thüringen," p. 85; Köhler, "Volksbrauch," p. 254.

† Festus, *s. v. everriator*; cf. Gray, "China," i, p. 287.

‡ Bancroft, "Native Races of the Pacific States," i, p. 641.

* Lichtenstein, "Travels in Southern Africa," i, pp. 258, 259; J. Campbell, "South Africa," p. 515, *sq.*; Taylor, "New Zealand," p. 170; Yates, "New Zealand," p. 86.

‖ Euripides, "Alcestis," v, 234 *sqq.*, cf. 205; Scholiast on Aristophanes, "Lysistrata," v, 611; Seneca, Epist. I, xii, 3; Gray, "China," i, p. 279. In modern Greece, as soon as the corpse is out of the house, the whole house is scoured (C. Wachsmuth, "Das alte Griechenland im neuem," p. 120).

△ Ralston, p. 318; Wuttke, §§ 736, 766.

◊ Sonntag, p. 169; Wuttke, §§ 737, 725; Gubernatis, "Usi funebri," p. 47; Lammert, "Volksmedezin," pp. 103, 105, 106.

‡ Dyer, "English Folk-lore," p. 230; Brand, "Popular Antiquities," ii, p. 231.

Bechuanas, Samoieds, Ojibways, Algonquins, Laosians, Hindoos, Thibetans, Siamese, Chinese, and Feejeeans. These special openings, or "doors of the dead," are still to be seen in a village near Amsterdam, and they were common in some towns of central Italy, as Perugia and Assisi.* A trace of the same custom survives in Thüringen, where it was thought that the ghost of a man who has been hanged will return to the house if the body be not taken out by a window instead of the door.†

The Siamese, not content with carrying the dead man out by a special opening, endeavor to make assurance doubly sure by hurrying him three times round the house at full speed—a proceeding well calculated to bewilder the poor soul in the coffin.‡

The Araucanians adopt the plan of strewing ashes behind the coffin as it is being borne to the grave, in order that the ghost may not be able to find his way back.*

The very general practice of closing the eyes of the dead appears to have originated with a similar object; it was a mode of blindfolding the dead, that he might not see the way by which he was carried to his last home. At the grave, where he was to rest forever, there was of course no motive for concealment; hence the Romans,‖ and apparently the Siamese,△ opened the eyes of the dead man at the funeral pyre, just as we should unbandage the eyes of an enemy after conducting him to his destination. The notion that, if the eyes of the dead be not closed, his ghost will return to fetch away another of the household, still exists in Germany, Bohemia, and England.◊ In some parts of Russia they place a coin on each of the dead man's eyes.‡

With a similar object, the corpse is carried out of the house feet foremost, for if he were carried out head foremost his eyes would be turned toward the door, and he might therefore find his way back. This custom is observed, and this reason is assigned for it, in many parts of Germany and among the Indians of Chili.‡ Conversely, in

* Yule on Marco Polo, i, p. 188; Crantz, "Greenland," i, p. 237; 'Tylor, "Prim. Cult.," ii, p. 26; Waitz, "Anthropologie," iii, p. 199; Williams and Calvert, "Feejee," p. 168; Sonntag, p. 51; Bastian, "Mensch," ii, p. 322; Klemm, ii, pp. 221, 225; id., iii, p. 293; C. Bock, "Temples and Elephants," p. 262; Pallegoix, "Siam," i, p. 245; Bowring, "Siam," i, p. 222; Gubernatis, p. 52; C. J. Anderson, "Lake Ngami," 466. A dead pope is carried out by a special door, which is then blocked up till the next pope dies.

† Wuttke, § 756.

‡ Pallegoix, "Siam," i, p. 245; Bowring, "Siam," i, p. 222. In some parts of Scotland the body used to be carried three times round the church (C. Rogers, "Social Life in Scotland," i, p. 167).

* Klemm, v, p. 51; Wood, "Natural History of Man," ii, p. 565.

‖ Pliny, N. H., xi, 150.

△ C. Bock saw that the eyes of a dead man at the pyre were open (in Siam), and he says that in Lao it was the custom to close the eyes of the dead ("Temples and Elephants," pp. 58, 261).

◊ Wuttke, § 725; Dyer, "English Folk-lore," p. 230; Grohmann, "Aberglauben," p. 188.

‡ Gubernatis, "Usi funebri," p. 50.

‡ Wuttke, § 736; Klemm, ii, p. 101.

Persia, when a man is setting out on a journey, he steps out of the house with his face turned toward the door, hoping thereby to secure a safe return.* In Thüringen and some parts of the north of England it used to be the custom to carry the body to the grave by a round-about way.†

I venture to conjecture that the old Roman usage of burying by night‡ may have originally been intended, like the customs I have mentioned, to keep the way to the grave a secret from the dead, and it is possible that the same idea gave rise to the practice of masking the dead—a practice common to the prehistoric inhabitants of Greece and to the Aleutian-Islanders.*

To a desire to deceive the dead man I would also refer the curious custom among the Bohemians of putting on masks and behaving in a strange way as they returned from a burial.‖ They hoped, in fact, so to disguise themselves that the dead man might not know and therefore might not follow them. Whether the wide-spread mourning customs of smearing the body with mud or paint, mutilating it by gashes, cutting off the hair or letting it grow, and putting on beggarly attire or clothes of an unusual color (black, white, or otherwise), may not have also originated in the desire to disguise and therefore to protect the living from the dead, I can not here attempt to determine. This much is certain, that mourning customs are always as far as possible the *reverse* of those of ordinary life. Thus, at a Roman funeral, the sons of the deceased walked with their heads covered, the daughters with their heads uncovered, thus exactly reversing the ordinary usage, which was that women wore coverings on their heads, while men did not. Plutarch, who notes this, observes that in like manner in Greece men and women during a period of mourning exactly inverted their usual habits of wearing the hair—the ordinary practice of men being to cut it short, that of women to leave it long.△

The objection, deeply rooted in many races, to utter the names of deceased persons,◊ sprang no doubt from a fear that the dead might hear and answer to his name. In East Prussia, if the deceased is called thrice by his name, he appears.‡ This reluctance to mention the names of the dead has modified whole languages. Thus among

* "Hajji Baba," c. i, *fin.*

† F. Schmidt, p. 94.

‡ Servius on Virg. Æn., i, 186. Night burial was sometimes practiced in Scotland (C. Rogers, "Social Life in Scotland," i, p. 161), and commonly in Thüringen (F. Schmidt, p. 96). Cf. Mungo Park, "Travels," p. 414.

* Schliemann, "Mycenæ," pp. 198, 219–223, 311 *sq.*; Bancroft, "Native Races," i, p. 93. The Aztecs masked their dead kings (Bancroft, ii, 606), and the Siamese do so still (Pallegoix, "Royaume de Siam," i, p. 247).

‖ Bastian, ii, p. 328.

△ Plutarch, "Rom. Quæst.," 14.

◊ Tylor, "Early History of Mankind," p. 142.

‡ Wuttke, § 754.

the Australians, Tasmanians, and Abipones, if the name of a deceased person happened to be a common name—e. g., the name of an animal, or plant—this name was abolished, and a new one substituted for it.* During the residence of the Jesuit missionary Dobritzhoffer among the Abipones, the name for tiger was thus changed three times.† Among the Indians of Columbia near relatives of a deceased person often change their names, under the impression that the ghost will return if he hears the familiar names.‡

I must pass lightly over the kindlier modes of barring the dead by providing for the personal comforts of the poor ghost in his long home. One instance, however, of the minute care with which the survivors will provide for the wants of the dead, in order that he may have no possible excuse for returning, I can not refrain from mentioning. In the German district of Voigtland,* with its inclement sky, they never forget to place in the coffin an umbrella and a pair of goloshes. Whether these utensils are intended for use in heaven, or elsewhere, is a question which I must leave to theologians.

A pathetic example is afforded by some Indian tribes of New Mexico, who drop milk from the mother's breast on the lips of her dead babe.‖

The nearly universal practice of leaving food on the tomb, or of actually passing it into the grave by means of an aperture or tube, is too well known to need illustration. Like the habit of dressing the dead or dying in his best clothes,△ it probably originated in the selfish but not unkindly desire to induce the perturbed spirit to rest in the grave, and not come plaguing the survivors for food and raiment.

Merely mentioning the customs of building a little house for the accommodation of the soul either on the grave or on the way to it,◊ and of leaving straw on the road, in the hope that the weary ghost would sit down on it and never get as far as the house,‡ I now come to two modes of barring the ghost, which from their importance I have reserved to the last—I mean the methods of barring the ghost by fire and water.

First, by fire. After a funeral certain heathen Siberians, who greatly fear the dead, seek to get rid of the ghost of the departed by leaping over a fire.‡ Similarly at Rome, mourners returning from a

* Tylor, ibid., p. 144 *sqq.*

† Klemm, ii, p. 99; Dobritzhoffer, "The Abipones," ii, p. 208 *sqq.*

‡ Bancroft, "Native Races," i. p. 248.

* Wuttke, § 734.

‖ Bancroft, i, p. 360.

△ Gray, "China," i, pp. 278–280; Klemm, ii, pp. 104, 221, 225; id. iv, p. 38; Marshall, "Travels among the Todas," p. 171.

◊ Klemm, ii, p. 297; Bastian, ii, p. 328; Marco Polo, i, c. 40; Waitz, "Anthropologie," ii, p. 195; id., iii, p. 202; Chalmers and Gill, "New Guinea," p. 56.

‡ Wuttke, § 739; Töppen, p. 109.

‡ Meiners, "Geschichte der Religionen," ii, p. 303.

funeral stepped over fire,* and in China they sometimes do so to this day.† Taken in connection with the Siberian custom, the original intention of this ceremony of stepping over fire at Rome and in China can hardly have been other than that of placing a barrier of fire between the living and the dead. But, as has been the case with so many other ceremonies, this particular ceremony may well have been practiced long after its original intention was forgotten. For customs often live on for ages after the circumstances and modes of thought which gave rise to them have disappeared, and in their new environment new motives are invented to explain them. As might have been expected, the custom itself of stepping over fire often dwindled into a mere shadow of its former self. Thus the South Slavonians returning from a funeral are met by an old woman carrying a vessel of live coals. On these they pour water, or else they take a live coal from the hearth and fling it over their heads.‡ The Brahmans contented themselves with simply touching fire,* and in Ruthenia the mourners merely look steadfastly at the stove or place their hands on it.‖

So much for the barrier by fire. Next for the barrier by water. "The Lusatian Wends," says Ralston,^ "still make a point of placing water between themselves and the dead as they return from a burial, even breaking ice for the purpose if necessary." In many parts of Germany, in modern Greece, and in Cyprus, water is poured out behind the corpse when it is carried from the house, in the belief that, if the ghost returns, he will not be able to cross it.◊ Sometimes by night they pour holy water before the door; the ghost is then thought to stand and whimper on the farther side.‡ The inability of spirits to cross water might be further illustrated from the Bagman's ghastly story in Apuleius,‡ from Paulus's "History of the Lombards,"‡ from Giraldus Cambrensis's "Topography of Ireland,"** and from other sources.††

Another way of enforcing the water barrier was for the mourners to plunge into a stream in the hope of drowning, or at least shaking off, the ghost. Thus, among the Matamba negroes, a widow is bound

* Festus, *s. v. aqua et igne.*

† Gray, "China," i, pp. 287, 305.

‡ Ralston, "Songs," p. 319.

* Monier Williams, "Religious Life and Thought in India," pp. 283, 288.

‖ Ralston, *l. c.*

^ "Songs of the Russian People," p. 320.

◊ Wuttke, § 737; A. Kuhn, "Märkische Sagen," p. 368; Temme, "Volkssagen der Altmark," p. 77; Lammert, p. 105; Panzer, "Beitrag," i, p. 257; "Folk-lore Journal," ii, p. 170; Töppen, "Aberglauben aus Masuren," p. 108; C. Wachsmuth, "Das Alte Griechenland im neuem," p. 119.

‡ Wuttke, § 748.

‡ "Metamorphoses," i, 19, cf. 13.

‡ iii, c. 34.

** Ch. 19.

†† Grimm, "Deutsche Mythologie," iii, p. 434; Theocritus, 24, 92, 93; Homer, "Odyss," xi, 26 *sqq.*, Ovid, "Fasti," v, 441; Brent, "The Cyclades," pp. 441, 442; Dennys, "Folk-lore of China," p. 24; Lammert, "Volksmedezin," p. 103.

hand and foot by the priest, who flings her into the water several times over, with the intention of drowning her husband's ghost, who may be supposed to be clinging to his unfeeling spouse.* In Angola, for a similar purpose, widows adopt the less inconvenient practice of ducking their late husbands.† In New Zealand all who have attended a funeral betake themselves to the nearest stream and plunge several times, head under, in the water.‡ In Feejee the sextons always washed themselves after a burial.* In Tahiti all who assisted at a burial fled precipitately and plunged into the sea, casting also into the sea the garments they had worn.‖ In some parts of West Africa, after the corpse has been deposited in the grave, "all the bearers rush to the water-side and undergo a thorough ablution before they are permitted to return to the town." △

But the barrier by water, like the barrier by fire, often dwindled into a mere stunted survival. Thus, after a Roman funeral it was enough to carry water three times round the persons who had been engaged in it and to sprinkle them with the water.◊ In China, on the fifth day after a death, the mourners merely wash their eyes and sprinkle their faces three times with water.‡ In Cappadocia and Crete persons returning from a funeral wash their hands.‡ In Samoa they wash their faces and hands with hot water.‡ In ancient India it was enough merely to touch water.** In Greece, so long as a dead body was in the house, a vessel of water stood before the street-door that all who left the house might sprinkle themselves with it.†† Note that in this case the water had to be fetched from another house—water taken from the house in which the corpse lay would not do. The significance of this fact I shall have occasion to point out presently.

When considered along with the facts I have mentioned, it can hardly be doubted that the original intention of this sprinkling with water was to wash off the ghost who might be following from the house of death; and in general I think we may lay down the rule that, wherever we find a so-called purification by fire or water from pollution contracted by contact with the dead, we may assume with much probability that the original intention was to place a physical

* Sonntag, p. 113. † Id., p. 115.

‡ Yates, "New Zealand," p. 137; Klemm, iv, p. 305.

* Williams and Culvert, "Feejee," p. 163, ed. 1870.

‖ Ellis, "Polynesian Researches," i, p. 403.

△ Wilson, quoted by Gardner, "Faiths of the World," i, p. 938; cf. Brinton, "Myths of the New World," p. 133; Ellis, "History of Madagascar," i, p. 238.

◊ Virgil, "Æn.," vi, 228, where Servius speaks of carrying *fire* round similarly.

‡ Gray, "China," i, p. 305.

‡ Wachsmuth, p. 120.

‡ Turner, "Polynesia," p. 228.

** Monier Williams, "Religious Thought and Life in India," pp. 283, 288.

†† Pollux, viii, 65; Hesychius and Suidas, *s.v.*, ἀρδάνιον. Cf. Wachsmuth, ibid., p. 109.

barrier of fire or water between the living and the dead, and that the conceptions of pollution and purification are merely the fictions of a later age, invented to explain the purpose of a ceremony of which the original intention was forgotten. Time forbids me to enter into the wider question whether *all* forms of so-called ceremonial purification may not admit of a similar explanation. I may say, however, that there is evidence that some at least of these forms are best explained on this hypothesis. To one of the most important of these forms of purification—that of mothers after childbirth—reference will be made in the course of this paper.

Such, then, are some of the modes adopted for the purpose of excluding or barring the ghost. Before quitting the subject, however, I wish to observe that, as the essence of these proceedings was simply the erection of a barrier against the disembodied spirit, they might be, and actually were, employed for barring spirits in other connections. Thus, for example, since to early man death means the departure of the soul out of the body, it is obvious that the very same proceedings which serve to exclude the soul after it has left the body—i. e., to bar the ghost, may equally well be employed to bar the soul *in* the body—i. e., to prevent it escaping; in other words, they may be employed to prevent a sick man from dying—in fact, they may be used as cures. Thus the Chinese attempt to frighten back the soul of a dying man into his body by the utterance of wild cries and the explosion of crackers, while they rush about with extended arms to arrest its progress.* The use of water as a means of intercepting the flying soul is perhaps best illustrated by the Circassian treatment of the sick. It is well known that according to primitive man the soul of a sleeper departs from his body to wander far away in dreamland; in fact, the only distinction which early man makes between sleep and death is that sleep is a temporary, while death is a permanent, absence of the soul. Obviously, then, on this view, sleep is highly dangerous to a sick man, for if in sleep his soul departs, how can we be sure that it will come back again? Hence, in order to insure the recovery of a sick man, one of the first requisites is to keep him from sleeping. With this intention the Circassians will dance, sing, play, and tell stories to a sick man by the hour. Fifteen to twenty young fellows, naturally selected for the strength of their lungs, will seat themselves round his bed and make night hideous by singing in chorus at the top of their voices, while from time to time one of their number will create an agreeable variety by banging with a hammer on a plowshare which has been thoughtfully placed for the purpose by the sick man's bed. But if, in spite of these unremitting attentions, the sick man should have the misfortune to fall asleep—mark what follows—they immediately dash

* Huc, "L'Empire Chinois," ii, p. 241.

water over his face.* The intention of this latter proceeding can hardly be doubtful—it is a last effort to stop the soul about to take flight forever. So among the Abipones, a dying man is surrounded by a crowd of old crones brandishing rattles, stamping and yelling, while every now and then one of them flings water over his face so long as there is breath left in his body.† The same practice of throwing water over the sick is observed also in China, Siam, Siberia, and Hungary.‡

By analogy, the origin of the Caffre custom of kindling a fire beside a sick person,* the Russian practice of fumigating him,‖ and the Persian practice of lighting a fire on the roof of a house where any one is ill,△ may perhaps be found in the intention of interposing a barrier of fire to prevent the escape of the soul. For, with regard to the custom of lighting a fire on the roof, it is a common belief that spirits pass out and in through a hole in the roof.◊ In the same way I would explain the extraordinary custom in Lao and Siam of surrounding a mother after childbirth with a blazing fire, within which she has regularly to stay for weeks after the birth of the child.‡ The object, I take it, is to hem in the fluttering soul at this critical period with an impassable girdle of fire. Conversely, among the Caffres a widow must stay by herself beside a blazing fire for a month after her husband's death—no doubt in order to get rid of his ghost.‡ If any confirmation of this interpretation of the Siamese practice were needed, it

* Klemm, iv, p. 34.

† Dobritzhoffer, "Account of the Abipones," ii, p. 266. Among the Indians of Lower California, if a sick man falls asleep, they knock him about the head till he wakes, with the sincere intention of saving his life (Bancroft, i, p. 569). Similarly, Caffres when circumcised at the age of fourteen are not allowed to sleep till the wound is healed (Campbell, "Travels in South Africa," p. 514).

‡ Gray, i, p. 278; Pallegoix, i, p. 294; Bowring, i, p. 121; Klemm, x, 254: "Folk-lore Journal," ii, p. 102. In Tiree a wet shirt is put on the patient, id., i, p. 167.

* Lichtenstein, i, p. 258.

‖ Ralston, "Songs of the Russian People, p. 380.

△ Klemm, vii, p. 142.

◊ Wuttke, §§ 725, 755; Bastian, "Mensch," ii, pp. 319, 323; id., "Die Seele," p. 15; Ralston, "Songs," p. 314; J. T. Brent, "The Cyclades," p. 437; Dennys, "Folk-lore of China," p. 22; Lammert, "Folksmedezin," p. 103.

‡ Carl Bock, "Temples and Elephants," p. 259; Bowring, i, p. 120; Pallegoix, i, p. 223. Cf. Forbes, "British Burmah," p. 46; Darmesteter, "Zend-Avesta," i, p. xciii; Ellis, "History of Madagascar," i, p. 151. A relic of this custom is seen in the old Scotch practice of whirling a fir-candle three times round the bed on which the mother and child lay (C. Rogers, "Social Life in Scotland," i, p. 135). Among the Albanians a fire is kept constantly burning in the room for forty days after birth; the mother is not allowed to leave the house all this time, and at night she may not even leave the room; and any one during this time who enters the house by night is obliged to leap over a burning brand (Hahn, "Albanesische Studien," p. 149). In the Cyclades, for many days after a birth, no one may enter the house by night. The mother does not go to church for forty days after the birth (Brent, pp. 180, 181).

‡ Lichtenstein, i, p. 259.

would seem to be found in the fact that, during her imprisonment within the fiery circle, the woman washes herself daily for a week with a mixture of salt and water,* for salt and water, as we know from Theocritus,† is a regular specific against spirits.

Of course it is possible that these fiery barriers may also be intended to keep off evil spirits, and this is the *second* supplementary use to which the proceedings for barring ghosts may be turned. This would appear to have been the object with which, in Siberia, women after childbirth cleansed themselves by leaping several times over a fire, exactly as we saw that in Siberia mourners returning from a funeral leap over a fire for the express purpose of shaking off the spirit of the dead.‡

In China, the streets along which a funeral is to pass are previously sprinkled with holy water, and even the houses and warehouses along the street come in for their share, in case some artful demon might be lurking in a shop, ready to pounce out on the dead man as he passed.# Special precautions are also taken by the Chinese during the actual passage of the funeral; in addition to the usual banging of gongs and popping of crackers, an attempt is made to work on the cupidity of the demons. With this view bank-notes are scattered, regardless of expense, all along the road to the grave. The notes, I need hardly observe, are bad, but they serve the purpose, and, while the ingenuous demons are engaged in the pursuit of these deceitful riches, the soul of the dead man, profiting by their distraction, pursues his way tranquilly behind the coffin to the grave.‖

In the Hervey Islands, in the South Pacific, after a death the ghosts or demons are fought and soundly pummeled by bodies of armed men, just as the Samogitians and old Prussians used to repel the ghostly squadrons by sword-cuts in the air.△

In Christian times bells have been used for a like purpose; this, of course, was the intention of the passing-bell.◊ The idea that the sound of brass or iron had power to put spirits to flight prevailed also in classical antiquity,‡ from which it was perhaps inherited by mediæval Christianity.

I have still one observation to make on the means employed to bar ghosts, and it is this. The very same proceedings which were resorted

* Bock, *op. cit.*, p. 260. † xxiv, 95, 96.

‡ Meiners, "Geschichte der Religionen," ii, p. 107.

Gray, "China," i, p. 299.

‖ Huc, "L'Empire Chinois," ii, p. 249; Gray, *l. c.*; Doolittle, "Social Life of the Chinese," p. 153 (ed. Paxton Hood).

△ Gill, "Myths and Songs from the South Pacific," p. 269; Bastian, ii, p. 341. Cf. Wood, "Nat. Hist. of Man," ii, p. 562.

◊ Brand, "Popular Antiquities," ii, p. 202; Forbes Leslie, "Early Races of Scotland," ii, p. 503.

‡ Lucian, "Philopseudes," c. 15; Ovid, "Fasti," v, 441; cf. Professor Robertson Smith in "Journal of Philology," vol. xiii, No. 26, p. 283, *note*.

to *after* the burial for the purpose of barring the ghost were *avoided* so long as the corpse was in the house, from fear no doubt of hurting and offending the ghost. Thus we saw that an axe laid on the threshold or a knife hung over the door after the coffin has been carried out, has power to exclude the ghost, who could not enter without cutting himself. Conversely, so long as the corpse is still in the house, the use of sharp-edged instruments should be avoided in case they might wound the ghost. Thus for seven days after a death, the corpse being still in the house, the Chinese refrain from the use of knives and needles and even of chopsticks, eating their food with their fingers.* So at the memorial feasts to which they invited the dead, the Russians ate without using knives.† In Germany a knife should not be left edge-upward, lest it hurt the ghosts or the angels.‡ They even say that if you see a child in the fire and a knife on its back, you should run to the knife before the child.* Again, we saw that the Romans and the Germans swept the ghost, without more ado, out of his own house. On the other hand, the more considerate negroes on the Congo abstain for a whole year from sweeping the house where a man has died, lest the dust should annoy the ghost.‖ Again, we have seen the repugnance of ghosts to water. Hence, when a death took place, the Jews used to empty all the water in the house into the street, lest the ghost should fall in and be drowned.^ In Burmah, when the coffin is being carried out, every vessel in the house containing water is emptied.◊ In some parts of Bohemia, after a death, they turn the water-butt upside down, because, if the ghost happened to bathe in it and any one drank of it afterward, he would be a dead man within the year.‡ We can now appreciate the significance of the fact mentioned above, that in Greece the lustral water before the door of a house where a dead body lay had always to be fetched from a neighboring house. For, if the water had been taken from the house of death, who could tell but that the ghost might be disporting himself in it?‡ In Pomerania, even *after* a burial, no washing is done in the house for some time, lest the dead man should be wet in his grave.‡ Among the old Iranians no moisture was allowed to rest on the bread

* Gray, "China," i, p. 288.

† Ralston, "Songs of the Russian People," p. 321.

‡ Grimm, "Deutsche Mythologie," iii, pp. 441, 454; Tettau u. Temme, p. 285; Grohmann, p. 198.

* Grimm, ibid., p. 469.

‖ Bastian, "Mensch," ii, p. 323. On the day of the funeral the Albanians refrain from sweeping the place on which the corpse lay. Hahn, "Albanesische Studien," p. 152.

^ Gardner, "Faiths of the World," i, p. 676.

◊ Forbes, "British Burmah," p. 95.

‡ Grohmann, § 193.

‡ Hence among the Jews all *open* vessels in the chamber of death were "unclean" Numbers xix, 15).

‡ Wuttke, § 737.

offered to the dead, for, of course, if the bread was damp, the ghost could not get at it.*

Once more, we saw that fire was a great stumbling-block to ghosts. Hence in the Highlands of Scotland and in Burmah the fires in a house used always to be extinguished when a death took place, no doubt lest they should burn the ghost.† So in old Iran no fire was allowed to be used in the house for nine days after a death,‡ and in later times every fire in the Persian Empire was extinguished in the interval between the death and burial of a king.*

It might perhaps be thought that the common practice of *fasting* after a death was a direct consequence of this disuse of fire; and there are facts which appear at first sight to show that it was so. Thus the Chinese, though they are not allowed to cook in the house for seven days after a death, are not prohibited from eating food which has been prepared elsewhere; indeed, during this period of mourning their wants are regularly supplied by their neighbors.‖ From this it would appear that the prohibition only extends to food cooked in the house of mourning. But this explanation will not suit the German superstition, that while the passing-bell is tolling no one within hearing should eat.^ For here the prohibition evidently extends to all the food in the neighborhood. The key to the solution of this problem will perhaps be found in the Samoan usage.◊ We are told that in Samoa, "while a dead body is in the house, no food is eaten under the same roof; the family have their meals outside or in another house. Those who attended the deceased were formerly most careful not to handle food, and for days were fed by others as if they were helpless infants." Observe here, firstly, that the objection is not to *all* eating, but only to eating under the same roof with the dead; and, secondly, that those who have been in contact with the dead may eat but may not touch their food. Now, considering that the ghost could be cut, burned, drowned, bruised with stones, and squeezed in a door (for it is a rule in Germany not to slam a door on Saturday for fear of jamming a ghost),‡ it seems not unreasonable to suppose that a ghost could be

* Spiegel, "Eranische Alterthumskunde," iii, p. 705.

† Brand, ii, p. 235; James Logan, "The Scottish Gaël," ii, p. 387; Forbes, "British Burmah," p. 94.

‡ Spiegel, ibid., p. 706.

* Diodorus, xvii, c. 114.

‖ Gray, "China," i, pp. 287, 288. Cf. Apuleius, "Metam.," ii, c. 24. Similarly among the Albanians there is no cooking in the house for three days after a death, and the family is supported by the food brought by friends. Hahn, "Albanesische Studien," p. 151. So among the Cyclades, Brent, "The Cyclades," p. 221.

^ W. Sonntag, "Todtenbestattung," p. 175. Similar superstition in New England ("Folk-lore Journal," ii, p. 24).

◊ Turner, "Nineteen Years in Polynesia," p. 228; cf. Taylor, "New Zealand," p. 163; "Old New Zealand, by a Pakeha Maori," p. 124 *sqq.*; Ellis, "Polynesian Researches," i, p. 402.

‡ Wuttke, § 752.

eaten, and if we make this supposition I venture to think that we have a clew to the origin of fasting after a death. People in fact originally refrained from eating just in those circumstances in which they considered that they might possibly in eating have devoured a ghost. This supposition explains why, so long as the corpse is in the house, the mourners may eat outside of the house but not in it. Again, it explains why those who have been in contact with the dead and have not yet purified themselves (i. e., have not yet placed a barrier between themselves and the ghost) are not allowed to touch the food they eat; obviously the ghost might be clinging to them and might be transferred from their person to the food, and so eaten.

This theory further explains the German superstition mentioned above, that no one within hearing must eat while the passing-bell is tolling. For the passing-bell is rung when a soul is issuing for the last time from its mortal tabernacle, and, if any one in the neighborhood were at this moment to eat, who knows but that his teeth might close on the passing soul? This explanation is confirmed by the companion superstition that no one should sleep while the passing-bell is tolling, else will his sleep be the sleep of death.* Put into primitive language, this means that, as the soul quits the body in sleep, if it chanced in this, its temporary absence, to fall in with a soul that was taking its eternal flight, it might, perhaps, be coaxed or bullied into accompanying it, and might thus convert what had been intended to be merely a ramble, into a journey to that bourn from which no traveler returns.

All this time, however, Plutarch has been waiting for his answer; but, perhaps, as he has already waited two thousand years, he will not object to be kept in suspense a very little longer. For the sake of brevity in what remains, I will omit all mention of the particular usages upon a comparison of which my answer is based, and will confine myself to stating in the briefest way their general result.

We have seen the various devices which the ingenuity of early man struck out for the purpose of giving an "iron welcome to the dead." In all of them, however, it was presupposed that the body was in the hands of the survivors, and had been by them securely buried; that was the first and most essential condition, and, if it was not fulfilled, no amount of secondary precautions would avail to bar the ghost.

But what happened when the body could not be found, as when the man died at sea or abroad? Here the all-important question was, What could be done to lay the wandering ghost? For wander he would, till his body was safe under the sod, and, by supposition, his body was not to be found. The case was a difficult one, but early man

* Sonntag, ibid.; cf. Wuttke, § 726. In Scotland it was an old custom not to allow any one to sleep in the house where a sick person was at the point of death (C. Rogers, "Social Life in Scotland," i, p. 152).

was equal to it. He buried the missing man *in effigy*,* and, according to all the laws of primitive logic, an effigy is every bit as good as its original.† Therefore, when a man is buried in effigy with all due formality, that man is dead and buried beyond a doubt, and his ghost is as harmless as it is in the nature of ghosts to be.

But it occasionally happened that this burial by proxy was premature—that, in fact, the man was not really dead, and, if he came home in person and positively declined to consider himself as dead, the question naturally arose, Was he alive, or was he dead? It was a delicate question, and the solution was ingenious. The man was dead, certainly—that was past praying for. But then he might be born again; he might take a new lease of life. And so it was; he was put out to nurse, he was dressed in long-clothes—in short, he went through all the stages of a second childhood.‡ But, before he was eligible even for this pleasing experience, he had to overcome the initial difficulty of getting into his own house. For the door was as ghost-proof as fire and water could make it, and *he* was a ghost. As such, he had to do as ghosts do: in fact, not to put too fine a point on it, he had to come down the chimney.* And down the chimney he came—and this is an English answer to a Roman question.—*The Contemporary Review.*

THE PHYSIOLOGY OF COLORS.‖

By M. E. MASCART.

A LIGHT is defined by two qualities, brightness and color. The comparison of two lights of the same color can be made without the assistance of our eyes, and by physical means alone, but it is impossible to compare different colors without bringing in the intervention of the physiological impression. It has been known since Newton's experiments that white light, or, to be more precise, the light of the sun, is formed of a large number of different colors, and that the union of all these in equal proportion, acting upon the eye, either

* The practice of burial in effigy prevailed in ancient Greece, Mexico, and Samoa, and it prevails to this day in modern Greece, Albania, India, and China. See Chariton, iv, c. 1; Bancroft, "Native Races of the Pacific States," ii, p. 616; Turner, "Samoa," p. 150; C. Wachsmuth, "Das Alte Griechenland im neuem," p. 113; Hahn, "Albanesische Studien," p. 152; Monier Williams, "Religious Thought and Life in India," p. 300; Gray, "China," i, p. 295. Compare Doolittle, "Social Life of the Chinese," p. 164; Apulcius, "Metam.," i, c. 6; Brent, "The Cyclades," pp. 223, 224; Servius on Virgil, "Æn.," vi, 366.

† For evidence see Tylor's "Early History of Mankind," p. 116 *sqq.*

‡ Plutarch, "Rom. Quæst.," v.

* See the passages cited in note ** to p. 678.

‖ An address before the Royal Institution of Great Britain. Translated from the French for "The Popular Science Monthly."

simultaneously or at very close intervals, produces the impression of white. Starting from a preconceived analogy with the notes of the gamut, Newton divided the solar spectrum, or the image obtained by decomposing white light with a refracting prism, into seven different colors. This division is really arbitrary, for the colors pass from one to another by insensible transitions, and each of them may be characterized either by the degree of its refraction in the prism, or by the length of the undulations to which it corresponds.

When we collect a part of the spectral rays in one point, we obtain either one of the primitive colors in a greater or less state of purity, or a new tint. If we divide the spectrum arbitrarily into two parts and collect the rays of these parts separately, we obtain two distinct colors, the superposition of one of which on the other gives white light. The experiment can be performed with an ordinary spectrum divided arbitrarily into two parts ; and it is effected, we might say naturally, in the phenomena of rotatory polarization in which the most brilliant hues are shown.

We mention these properties to deduce two conclusions from them. We remark, first, that the mixture of simple or homogeneous lights in any proportion always produces upon the eye a single impression, that of one color. While the ear can distinguish all the notes that go to make up a harmony, the eye can grasp only one color, without being able to distinguish whether it is really simple, or is formed of different lights.

In the second place, the mixture of colors provokes only one new impression, that of purple, for example, which we may obtain by mixing red and violet, while the varieties of rose are nothing but mixtures of purple and white. White may be produced by two simple colors alone, as by red and green ; more generally, if we isolate three suitably chosen colors in the spectrum, such as particular shades of red, green, and violet, we may, by mixing them in different proportions, imitate the impressions produced by all the colors. Artificial colors, formed, for example, of rays selected from the spectrum, may be simple or compound, without the eye being informed of the difference, except, perhaps, when they have a shade of purple or of rose, for we know then that those colors do not exist in a simple state.

The same is the case with the colors of nature, or of industry. An object appears colored to us because it sends us only a part of the light it borrows from the general illumination. The sorting out is made either by transmission, as in colored glasses, or by reflection, as in the case of the metals, or by diffraction, as in the wings of some butterflies, or in the coronas which we sometimes perceive around the moon ; the portion of the light that does not reach the eye having been absorbed or sent off in a different direction. Leaving out of the account the effects of fluorescence, we perceive that objects do not have colors of themselves, but simply borrow from the general light-

ing the tint that is suited to them, and present very different aspects according to the mode in which they are lighted. A red ribbon, for example, placed successively in the different colors of the spectrum, appears black, except in the red region ; it therefore returns by reflection an almost homogeneous light. A rose ribbon appears very unequally luminous in different parts of the spectrum. The light which it reflects is, therefore, complex.

We may ask, then, What would be the condition of nature if the light that shines upon us were absolutely homogeneous? Some bodies would absorb it completely, and would appear dark like black velvet ; others would reflect it more or less actively, and would have a corresponding degree of brilliancy. As there would be no criterion for comparison, the eye would have only the sensations of white, black, and the intermediate rays.

Pascal said that nothing better enabled him to comprehend the properties of the air than what took place where there was none. So, nothing better enables us to comprehend the properties of colors than the appearance of the world under an illumination of homogeneous light. The volatilization of a salt of soda in the flame of a Bunsen burner almost perfectly fulfills this condition. With such a light, cloths dyed in the richest colors show only white, black, and gray, and the art of painting has no place.

The estimation of color being connected with the impression produced upon the retina, it is readily to be seen that the human eye will not always equally well perform that function. The different points of the retina are not alike ready to appreciate colors. To distinguish the details of an object, it is necessary to direct the look toward it, or, in other words, to produce an image upon the central region of the retina, where the acuteness of physiological perception is much the greatest. The same is the case for colors. When we keep the look in a determined direction, and put a colored body in the visual field in such a way that its image is produced laterally, we remark that the notion of color is more and more weakened as we remove from central vision, and disappears at the limits of the field. But the most important fact is, that in the different views the colors are not distinguished from one another with equal facility, and that we sometimes come to the point of confounding colors which really seem to be most discordant, as green and red. The discovery of this particular form of infirmity is due to Dalton, who was very strongly affected by it, and who carefully analyzed the errors of his judgment. This fault, which remained unperceived for so long a time, is in reality quite frequent. About ten persons in a hundred make mistakes in the comparison of colors marked enough to be detected by an attentive examination. Generally the imperfection is not accompanied with grave inconveniences, and is corrected unconsciously by the operation of habit, the recollection of objects, and the judgments of others. But the annoy-

ance becomes extreme when one can not distinguish, for example, red from green, a cherry or a ripe strawberry amid the foliage, or a green from a red light in railway or ship signals. Artists sometimes have marked predilections for certain colors. Lesueur put a profusion of blue into all his paintings, and Turner seems to have sought and found red everywhere. It might be worth while to investigate whether the choice of their favorite colors by some painters is wholly intentional, or is a consequence of a physiological state. Color-blind persons are generally so by birth, but the affection may sometimes be the result of an accident. In some nervous affections it is occasionally manifested temporarily and under the strangest forms. The sight may thus, more than the other senses, be the victim of numerous errors and illusions. To speak only of those which have relation to colors, I notice the effects of contrast of two neighboring colors, or those which follow the impression of an image, or the subjective colors we see with our eyes shut, the result of a mechanical action on the eye, and I shall limit myself to describing some experiments relative to the apparent relief of colors. When we examine on a screen the image of a spectrum produced by a direct-vision prism, the successive colors appear as if situated on the same plane; but, if we slowly turn the slit or the prism, we shall have the illusion of a colored blade in relief with the red extremity forward. The effect is more sensible when the slit is V-shaped, in which case the spectrum resembles a groove. If we substitute for the slit the word DAVY in transparent letters, there will appear to be produced on the screen an exaggerated form of letters in relief like those we see on some shop-signs.

Outside of the colors we are accustomed to see, the solar spectrum includes other rays, some less refrangible than the red, which make themselves manifest by their calorific properties, and others more refrangible than the violet, which are remarked by their photographic effects, and by the action they exercise on fluorescent substances. The solar ultra-violet spectrum produced in the prism occupies an extent nearly equal to that of the luminous spectrum; while Mr. Stokes has shown that the electric arc gives an ultra-violet spectrum five or six times more extended.

We may be surprised that the sight of man is restricted to so small a part of the rays emitted by a luminous source. We have to remark on this point that the case is the same with the other senses. The touch can give an idea of the temperature of bodies only within very narrow limits; the ear can perceive neither extremely grave nor extremely acute tones, and the highest sounds it can hear produce a painful impression. On the side of the infra-red, the visible spectrum stops very abruptly, and the efforts of Brewster extended the range of the rays that the eye can perceive only slightly. Visibility, on the other side of the spectrum, persists in a remarkable manner. Helmholtz had already discovered that with certain precautions he

could perceive the whole ultra-violet spectrum as it is revealed by photography. Having had occasion to study the light emitted by metallic vapors, I have ascertained that, with a prism of Iceland spar, an ordinary sight can distinguish an ultra-violet spectrum three or four times as extended as the luminous spectrum; one of my co-laborers saw much farther still, and pointed out in advance all the rays which it was possible for me to photograph. If instead of regarding the refraction of these rays, which varies with the nature of the substances, we define them by their wave-lengths or by the duration of their undulations, we may say that the ordinary luminous spectrum comprises the interval of an octave, and that it is possible to perceive a second higher or more acute octave.

Sir William Thomson has expressed surprise that Nature has forgotten to give us a special sense for perceiving the magnetic phenomena amid which we are living. In the case of light, we are in the presence of rays that are not luminous in sunlight, or at least are not seen by us, which are energetically absorbed by most transparent media and especially by the humors of the eye, for which we give ourselves no concern whatever in current life, and which nevertheless act upon the retina. Does it not seem as if we possessed in this respect a superfluous sensibility, and as if there were a lack of harmony between the structure of the organ and the wants to which it should respond? A question has been raised on this subject that presents a very great interest in the philosophical point of view, as to whether man is susceptible of an organic development, and if it is possible to detect a trace of any progress that may have been accomplished in the vision of colors, and consequently in the structure of the eye. An eminent Englishman has not disdained to engage himself with this question. Mr. Gladstone has summed up all the expressions used by Homer to designate the color of objects, from which it appears that the great poet was accustomed to apply the terms in a very uncertain manner, and confounded green with yellow and blue with black. Before concluding, from this curious observation, that the sense of color was but little developed in Homer's age, we should, perhaps, remark that the interval that separates us from him is but a short time in the history of mankind; that the Greeks afterward made much use of colors in their pictures and in the painted statuettes of which we possess numerous specimens; that the frescoes of Pompeii exhibit the most various colors; and that a careful examination of modern authors might lead us to draw the same conclusions with respect to their time as would be drawn from the Homeric writings. Is it not singular that in the middle of the seventeenth century, when Lesueur was using blue extensively in painting, that emphatically naturalistic poet, La Fontaine, did not once employ the term blue to designate any colored object or the color of the sky?

Even if mankind were capable of a rapid progress toward perfec-

tion, it might be supposed that peoples who have continued in the conditions of the Stone age, like the natives of Cape Horn, should not have participated in the general progress. The French expedition, that recently spent a year at Terra del Fuego, made a special study of the natives in respect to this point. The Fuegian language has terms for only two colors, one for red and analogous tints, the other for blue and green. But it is thus poor only because colors do not play an important part in Fuegian life, for it was found that with a little practice the people learned to distinguish and classify colors and their different shades with all the exactness of the most civilized European. The organic development of their visual apparatus, therefore, leaves nothing to be desired. The question whether the vision of animals is the same as that of man, or whether some of them may not have the faculty of perceiving rays to which we are insensible, has been taken up by M. Paul Bert. He placed in a glass vessel a number of fresh-water crustaceans of the family of *Daphneæ*. When light was cast upon a point in the vessel, the Daphnias precipitated themselves upon it and arranged themselves along the beam. Most animals show a similar disposition, and seek the light when it is not too glaring. When a spectrum was thrown upon the vessel, the Daphnias still spread themselves over the illuminated region, but with some quite remarkable peculiarities of arrangement. The smallest ones were scattered through the whole spectrum, being rare in the red, abundant in the yellow and green, and more numerous in the blue and violet, while some of them fixed themselves in the ultra-violet. The largest ones, however, were almost exclusively localized upon a narrow band situated between the green and the blue. These animals, then, see the same rays as we, notwithstanding the distance that separates them from us in the zoölogical scale, and even seem to share our infirmities, for some of them behaved as if they were affected by color-blindness. Sir John Lubbock has made a series of brilliant researches, in the laboratory of the Royal Institution, on the vision of ants, bees, and wasps, from which the curious result has been deduced that the ultra-violet rays appear brighter to ants than the ordinary luminous spectrum. The history of animals regarding this point would therefore be of the highest interest.

We have, so far, considered colors only as one of Nature's decorations, but their influence on the development of living beings is exercised under the most various conditions. Without doubt, light and colors act upon the condition of our mind, and the moral impression thus produced can be nothing but the translation of a physiological action. In some sanitary establishments, where mental disorders are treated, patients are sometimes kept in a yellow light, which seems to exercise a happy influence on their disposition, and to promote calmer feelings. It is not the yellow light of soda that produces this result, but a kind of white light, in which the extreme blue and red rays have

been softened so as to cause a predominance of the rose and yellow tones.

The predilection of animals for particular colors is not the result of an artistic preference. If the Daphnias seek the green light and the ants the ultra-violet, it is, doubtless, because they find better conditions of existence in them. Plants yield themselves more conveniently to studies of this kind. A common plant, like those we have habitually under our eyes, increases, develops itself in every quality, adds to its weight, produces leaves, flowers, and fruits, and respires, or keeps up a constant exchange between the elements it contains and the gases of the atmosphere. These different acts of vegetable life are very unequally affected by the various luminous or calorific radiations. The growth of plants, by the elongation and multiplication of cells, takes place mostly under the influence of the calorific rays, and there is for each plant a preferred temperature. If a plant receives heat only from one side, it is more developed on that side, and forms a curve in the opposite direction. This is the phenomenon of thermotropism. A plant grows less rapidly in the light than in the darkness, but with good effect on its general nutrition and transverse development. In this case the different colors have a very marked specific action. With a good light, the retarding action, insensible in the duller rays, exhibits a first maximum toward the red end, a minimum in the yellow, where the light is most intense, and a grand maximum in the violet. The rays of greater wave-length are, therefore, the more active ones. Hence results a very simple explanation of heliotropism, or of the marked tendency of plants to bend toward the light. When a plant is exposed to a lateral light, the illuminated parts lengthen less rapidly than those which remain in the shade, and the plant bends its head toward the light. We are able to go still further into the mechanism of nutrition. Besides the loss of water by evaporation, plants have two kinds of respiration—one which is continuous day and night, disengaging carbonic acid, a kind of combustion correlative with life and quite analogous to the respiration of animals; and the other intermittent, and taking place only in the light, the result of which is to borrow from the carbonic acid of the atmosphere the carbon from which the plant makes sugar and wood, and to disengage oxygen. The coloring-matter of the leaves, chlorophyl, plays the principal part in this nutritive respiration. Now, chlorophyl has to be made first, and then to perform its respiratory functions; and in this, again, the different colors act very unequally.

If we examine the formation of chlorophyl in the plant with a moderate light, we shall find that it takes place through the whole extent of the solar spectrum, very weakly in the infra-red, reaching a maximum in the deep yellow, and undergoing a regular diminution to the ultra-violet. The curve of this action takes a direction analogous to that which Fraunhofer has given for the distribution of lumi-

nous intensity in the spectrum, but is more prolonged toward the more refrangible rays. Here, again, is a preferred intensity, beyond which chlorophyl is formed less easily. Experiment has also shown that the production of oxygen takes place only where there are grains of chlorophyl. If we resolve with a prism a ray of white light that we have passed through a solution of chlorophyl, we will remark a strong absorption-band in the red, and two others in the blue and violet. These represent the rays that have been absorbed by the green substance, and which effect the reduction of carbonic acid.

In his experiments on fermentations, M. Pasteur distinguished the minute microscopic beings into *aërobes* and *anaërobes;* the former respire and are developed in the presence of the oxygen of the air, while the others are killed by oxygen. If we examine the aërobes of a liquid with the microscope, we will find them collected around bubbles of air, where they can find oxygen. If the liquid is deprived of air-bubbles and incloses a filament of a green alga, the bacteria will distribute themselves indifferently in the medium so long as it is illuminated with a very weak light, or, which is better, with a light that has been filtered through a solution of chlorophyl. In white light, the bacteria will be seen to precipitate themselves upon the grains of chlorophyl, to get the oxygen disengaged from them. They thus constitute a very delicate reagent. To witness the effect of the different colors, we let the microscopic spectrum fall upon a filament of conferva, or a transverse leaf-section. The bacteria will collect upon the plant in the red, at the point of maximum absorption, next in the blue, and the density of the population will nearly follow the absorption-curve of the coloring-matter.

I will not insist too long upon these facts in natural history; but I must add that great specific differences exist in the proper color of different plants, resulting from unequal absorption by their coloring-matters. One example of this kind will be enough. The color of sea-water varies according to the thickness through which we observe it, on account of the unequal absorption of the different rays; hence a marine plant will find itself in a condition more or less favorable, and be better or less equipped for the struggle for existence, according to the depth of the soil on which it rests. If we examine a bottom which the tide has just left, we will find blue sea-weeds on the edges of the deepest waters, farther down green sea-weeds, beyond these brown ones, and, lastly, red plants in the places which are least frequently uncovered. From the top of a bank we may thus perceive a series of concentric bands of different colors defining the limits within which each species, better fitted to the physical conditions, has overcome and eliminated the neighboring species. This is not a question of depth, because we find red sea-weeds at the water-level in sheltered places, the hollows of rocks, and deep caves, like the one at Capri, where the light comes in weakened.

Light, then, is an inexhaustible source from which living beings obtain energy under all forms and in the most unforeseen conditions; or, as Lavoisier has said, we might believe prophetically, considering the time when he spoke: "Organization, feeling, spontaneous movement, and life exist only at the surface of the earth, and in places exposed to the light. We might say that the fable of the torch of Prometheus was the expression of a philosophical truth that did not escape the ancients. Without light, nature would be bereft of life, dead, inanimate. A beneficent God in giving light has spread organization, feeling, and thought over the surface of the earth."

SKETCH OF DR. GUSTAV NACHTIGAL.

THE name of Dr. Gustav Nachtigal is associated with some of the most arduous achievements of African research, which were also not of inferior importance; and in the last year of his life he was prominent, as the designated servant of his Government, in those transactions which had for their object the establishment of German colonies and influence at commanding positions in the "Dark Continent."

Dr. NACHTIGAL was born on the 23d of February, 1834, at Eichstadt, near Stendal, in the former Prussian province of Altmark, where his father was a clergyman. He lost his father at an early age, and the burden of the support of himself and his little sister, as he used afterward to relate with grateful admiration of her heroic devotion, fell hard upon his poor widowed mother. Having received the usual primary education and completed his course at the gymnasium, he studied medicine at the schools in Berlin, Halle, Würzburg, and Greifswald. At the last place he was a pupil of the famous pathologist Niemeyer, and contracted from him, as he afterward told a friend, much of his enthusiasm for science. He received his doctor's degree here in the fall of 1857, passed the state examination during the ensuing winter, and was appointed under-physician to the thirtieth infantry regiment, which was stationed at Cologne. In 1859, he was promoted to be assistant-surgeon of the thirty-third regiment, also in Cologne. Two years later, when he received his furlough from active service, his superiors could say of him: "A thoroughly scientifically taught physician, Nachtigal is full of energy, and shows great devotion to his profession. His quiet self-possession, and his clear understanding, together with great tact in demeanor, attest that he is peculiarly well fitted to the higher positions of the military medical service."

In 1862, having been attacked with a disease of the lungs, which

the North-German climate promised only to aggravate, Nachtigal was compelled to seek a milder atmosphere in the south, and removed to Algiers, and afterward to Tunis, where he found a lucrative practice, and obtained a knowledge of the Arabic language, and of the manners and customs of the people, that proved useful to him in his future explorations. At Tunis he became physician to the Bey, whom he accompanied upon a campaign against some of his rebellious subjects.

Toward the end of 1868 Gerhard Rohlfs came to Tripoli, charged with a commission by the King of Prussia to dispatch an assortment of presents to Sultan Omar, of Bornoo, in acknowledgment of the hospitality he had given and the valuable services he had rendered to the German travelers Barth, Vogel, Overweg, Von Beurmann, and Rohlfs, who had at various times visited his capital, and in return for a silver-mounted harness which he had sent to his Majesty. King William was sending, in response to these favors, a fine collection of European manufactured goods, a throne-chair, and a portrait of himself. The occasion of this visit was the decisive point in Nachtigal's life. Rohlfs found in him just the man to carry the gifts to their destination, and he, the choice having been approved by Bismarck, left Tripoli, with his caravan of eight camels, on the 18th of February, 1869, on his long southern journey, traveling under the name of Edris Effendi. The first stopping-place was at Moorzook, the capital of Fezzan, where Nachtigal found that the country beyond was in so unsettled a condition, and the roads were so infested, that it would be futile to attempt to continue the journey at that time. Probably a year would have to pass before he could go on. He would not wait idly, and he resolved to use the occasion to make an excursion to the highland country of Tibesti, southeast of Fezzan, the ancient land of the Troglodytes, or cave-dwellers, which had long excited the interest of European travelers, but which no one had ever been able to reach. Its people, the Tibbu, had the worst reputation for robbery and treachery of all the Africans. Nachtigal attempted and made the journey from which all others had shrunk. He was smuggled secretly into the country by his guides. The party lost their way and wandered for many days through the desert without food or water, making a near approach to death by thirst. This, as a German biographer describes it, condensing from Nachtigal's own account, in the midst of summer in the burning wilderness, where two days without water meant death. Amid stones and sand, through barren ravines and over rocks, marched the travelers, their parched tongues cleaving to their mouths, and the half skin of water which they still had having to suffice for ten persons. The guide went upon a knoll to look around, while the rest of the party hung anxiously upon his eyes as he made his report, "None yet." The exhausted camels lay down, and Nachtigal by the side of one of them, to die, while the Mohammedan servants

prayed to be received into paradise. At last a few Tibbus attached to the caravan succeeded toward evening in getting some water and saved the lives of the party. Such was his manner of entering this forbidding land, while the savage inhabitants regarded him with suspicious hostility, believing that no good, only evil, could be in his intention. Nachtigal bought the protection of one of the chiefs at the expense of all he had, and was able to travel over the country and stay a month at the capital. Thence he returned, without guide or beast, with scant provision of food and a water-bag slung over his shoulders, and reached Moorzook, literally naked, at the end of October.

He was able, in the spring of 1870, to resume his journey to Bornoo, with the presents, which had remained at Moorzook while he was in Tibesti. He reached Kuka, the capital of Bornoo, on the 6th of June, and was received by Sultan Omar with a hospitality which would have been as marked had he brought no gifts, and with many expressions of appreciation of the presents. His mission here having been fulfilled, he availed himself of the friendship of the Sultan to make a journey of exploration to Berkû, Kânew, and Bagirmi, on Lake Chad. He spent a wretched life of nine months among highwaymen, but was able to accomplish much for science. He showed that the Bahr-el-Ghazul is an outlet from Lake Chad to the northeast during the rainy season, and made the acquaintance of the southern Tibbu, among whose northern relatives he had faced so many dangers a few months before.

Sultan Omar would not allow him to go to Wadai, east of Bornoo, for it was too dangerous a land; but he readily gave him a letter to the Sultan of Bagirmi, in the south, although a war was then raging there. With a hundred and fifty Maria-Theresa thalers, which he borrowed from a Tripolitan merchant on a note for double the amount, he bought goods and fitted out a caravan, and started on his journey early in 1872. He was well received by the Sultan, but came very near being debarred intercourse with the court on a question of ceremony. Every one who sought audience with his Majesty had to come barefooted. Nachtigal was willing to take off his shoes, but insisted on keeping his stockings on. There was considerable discussion over the matter, but the traveler carried his point and introduced a novelty at the court, for no one there had ever seen a man in stockings before. The Sultan was about to start on a campaign against a rival chief, and Nachtigal embraced the opportunity to go with him and see a country which had not been explored. The gain to science was purchased at great expense in the witnessing of cruelties, without power to protest against them, inflicted upon all adversaries who came in the way, and others—murders, torture, capture of slaves, and barbarities indescribable. In one of the battles Nachtigal was in great peril during a temporary rout of the Sultan's forces, from which they afterward recovered, and for which they paid their customary vengeance. Yet he was able to render some aid to humanity by surgical treatment

of the wounded, and he did what he could; but a large proportion of the cases, having received wounds in their vital parts, were past recovery. Having taken his leave of the Sultan of Bagirmi, Nachtigal, suffering a part of the time from fever, made his way through a flooded country, in which he had to wade or swim the rivers which he had before crossed almost dry, back to Kuka, in Bornoo, where he enjoyed another hospitable reception from Sultan Omar.

Nachtigal next undertook, in the face of what was considered extreme danger, to visit Wadai, on the eastern side of Lake Chad. It was a country of very bad repute. The only European who had ever reached it, Eduard Vogel, had been put to death by the command of the Sultan in 1856. Moritz von Beurmann, who had been sent out to learn Vogel's fate, had been murdered on the borders of the land. It took much courage even to think of a journey there, but Nachtigal had hope in the fact that a new Sultan, a more intelligent man than his predecessors, had come into power. He proceeded cautiously, in doubt as to what kind of a reception he might expect, but gradually found the way cleared, and was finally admitted to an audience from which he came away with a satisfaction he could not, he said in a letter to a friend, fully express. "I found Sultan Ali the most intelligent prince that reigns in all the Soudan, and was charmed with the friendly greeting he gave me. This was all the more remarkable, because, as I knew, he had at first hesitated to receive me, and was not at all glad that I had come." The murder of Vogel, eighteen years before, had been forgotten by most of the people, and the search for the papers he left was fruitless.

Nachtigal had by this time become quite exhausted with his five years of arduous travel and dangers, and early in 1874 started homeward. He went through Darfoor to Kordofan, where, meeting the Egyptian garrison, he almost felt as though he were in Europe. Khedive Ismail sent a steamer to bring him to Cairo, and was the first to receive him there. He stayed a year in Cairo to recover a degree of health, and then proceeded to Berlin, where he intended to make his home.

Here he at once assumed an active position among the scientific men interested in the promotion of geographical research. He was elected President of the German-African Society; was consulted by the King of the Belgians in the proceedings that have led to the formation of the Congo state, and was a most useful member of the Executive Committee of the "Association Internationale Africaine"; and was for three years in succession elected President of the German "Gesellschaft für Erdkunde," and was its representative at the International Congresses in Paris in 1875 and 1878, and in Venice in 1881. The Paris Geographical Society voted him its golden medal, and the other similar societies of the world gave him medals or diplomas of honor. He dwelt in Berlin till 1882, busily engaged most of the

time in performing the duties of his scientific commissions, and in preparing the narrative of his travels, his great work, "Sahara und Sudan," or "Experiences of Six Years of Travel in Africa" of which the first volume was published in 1879, and the second, bringing up the story to his departure from Bagirmi, in 1881; while the third is unfinished. In 1882 Germany needed a diplomatic representative in Tunis; Dr. Nachtigal was chosen as the most suitable man in the nation to fill the position. After remaining there three years as consul-general, a more important duty fell upon him—also by the designation of the great Chancellor of the Empire—that of going to the west coast of Africa to superintend the planting of the German colonies in the Togo country and the Cameroons. This was in May, 1884. He was there attacked by the fever which seems to be the inevitable doom of all white men who stay long on the Guinea coast. To get him away, if possible, from this scourge, he was put upon the German corvette Möve and sent to sea. On board this vessel, a few miles out from Cape Palmas, he died on the 20th of April of this year. His body was brought ashore and buried at Cape Palmas.

Dr. Nachtigal, says one of his German biographers, was one of the "strong and enthusiastic representatives of German learning, uniting with complete devotion to science a heart warmly inspired with the idea of spreading abroad the power and civilization of the Fatherland; and he regarded it an object of life to press forward into unexplored lands and ever to be adding new objects to scientific cognizance."

"With Nachtigal," says Dr. Karl Müller, in "Die Natur," "has passed away one of the brightest stars of the literature of travel; a man who, treading in the footsteps of a Barth, was, like him, so happy as to come back and contribute no little in his turn to our knowledge of Central Africa. . . . With fifty-one years upon him, he still bore the expectancy of a longer life, even though the old chest-disease he had suffered from at home had not entirely passed away. For we had learned to know and esteem him all the more highly because in spite of his disease he was among the most active and most lively. His fate," Dr. Müller adds, "is a sad answer from West African Nature to German colonizing ambitions."

Everything living, said his friend Dr. Paul Güssfeldt, in a memorial address, "seemed to arouse his sympathy. His love for animals was particularly touching. I can hardly avoid a sorrowful laugh today when I think of his contracted house in Berlin, which he shared with a parrot and three little dogs as companions having equal rights. . . . What to others seemed a legitimate hunter's shot, to him, who himself had barely a hold on life, was murder. It is well known that Nachtigal, during the whole course of his travels, never fired a gun. The fact points out one of his strong characteristics. It shows that neither necessity nor fearful peril, such as he was exposed to in Bagirmi, could disturb the delicate stringing of his soul."

CORRESPONDENCE.

AERIAL NAVIGATION.

Messrs. Editors:

SIR: The writer of the paper in the July Monthly on aërial navigation is certainly mild in his predictions of success, and still he is much too sanguine, as it seems to me. Besides the employment of a new motor, the recent French experiments have accomplished nothing not done before. If anything, they have emphasized the difficulties long recognized by aëronauts, without bestowing an iota of anything valuable toward their solution.

An enormous gas-bag is employed to encounter atmospheric resistance, and then to overcome that resistance a motive power is employed. It is the old way. One would think that effort would stop in this direction. It seems to be an infatuation similar to the "perpetual-motion" craze, just as persistent and just as hopeless.

As long as atmospheric resistance on any sort of a gas-bag is so much greater than the power developed by any known motor it is capable of carrying, the task of making a practical air-traveling machine is an impossible one.

It is the humming-bird process, and seems unfitted to man's use. Why not try the albatross or condor method, where gravity is the motive power, all active mechanism being dispensed with, and shape and position brought into prominence as the factors of success? Respectfully,

I. LANCASTER.

335 WABASH AVENUE,
CHICAGO, *June* 29, 1885.

HOW THE LOCUST LAYS ITS EGGS.

Messrs. Editors:

DEAR SIR: During the appearance of the so-called seventeen-year "locust" (*Cicada septendecim*) at this place in 1868, the commonly accepted account of the manner in which the female deposited her eggs in the twigs of trees included the statement that a transverse incision was made by the insect below the place where the eggs were deposited, causing the twig to break off and hang by the bark only. This was supposed to serve an important purpose in the hatching of the eggs, and was regarded as a remarkable exhibition of instinct on the part of the insect. The fact that the whole woods became brown with dead twigs seemed to give color to the statement. But, having carefully observed the process during the present appearance, it is very clear that the breaking is accidental, and disastrous to the eggs, rather than premeditated and beneficial. No incision is made, other than those in which the eggs are placed. Only a small part of the twigs break, and they without any regularity as to the place of fracture.

Another erroneous statement, which is frequently made, is that the eggs are laid in parallel furrows. The incisions in the wood are V-shaped, starting from a single small hole through the bark at the angle of the V. The furrows are sunk deeply into the hardest part of the wood, the eggs placed in the bottom, and left thickly covered with the hair-like fibers of the wood displaced in making the trench, and left attached at one end. The form of the incision seems to be due to the necessity of placing the eggs in solid wood, avoiding the pith. In a number of instances where the incision had accidentally penetrated the pith, the furrow was left incomplete, and no eggs were deposited.

As may be supposed, ovipositing is attended with great labor on the part of the female. Each thrust of the ovipositor requires a severe and prolonged struggle; each furrow, judging by the number of displaced fibers, must require from twenty-five to forty thrusts; and each female makes many separate furrows. CHARLES B. PALMER.

YELLOW SPRINGS, OHIO, *July* 7, 1885.

EDITOR'S TABLE.

SCIENCE VERSUS IMMORALITY.

SELDOM has the moral sentiment of the civilized world received so severe a shock as it has done in connection with the revelations which a prominent London newspaper has made, within the last couple of months, of the gross and inhuman vices practiced in the metropolis of the British Empire. One of the worst features in the case is the fact that the enormities referred to have been committed, not by the "dregs of the population," as that expression is commonly understood, but by men of

wealth and social station. "Gentlemen" (!) of education (save the mark!) and leisure have employed, annually, in the corruption of female youth and childhood, sums that would have afforded decent maintenance to numbers of poor families. Men whose own condition of life had been made in every way desirable, so far as money could accomplish that object, have found nothing better to do than to employ their means in spreading moral contagion and destruction among the families of the poor. Men who boast the name of Englishmen have thought it not beneath them to trade in the souls and bodies of unfortunate children. England, as a nation, struck the manacles from the hands of her negro slaves over fifty years ago; but some Englishmen to-day, belonging to the most favored social class, do not hesitate to practice, upon weaker members of their own race, crimes worse than those which made slavery a hissing and an abomination among the civilized races of mankind.

It is needless, however, to dwell further on the facts. Words can but feebly express the shame and horror that they involve. What we may do with advantage is to consider whence such evils spring, and what is their most effectual remedy.

As regards the unhappy victims of the rich man's lust, there is an economic side to the problem which is doubtless difficult to deal with. That the pressure of life should be so hard upon some, as to render the path of virtue one almost impossible to tread, is in itself an evil of the first magnitude, and one which a more fully developed economic science must some day grapple with. The efforts at present being made, under the guidance of a purely sentimental impulse, to provide improved dwellings for the poor, and in other ways to force on them higher modes of living, we do not, we must confess, regard as very hopeful. It is seldom that the state succeeds in paying Peter without robbing Paul, or in closing the door to one social abuse without opening it to another and perchance a greater. The economic problem, however, is not the only one to consider, nor is it perhaps the most important. The educational problem demands equal and more immediate attention, seeing that the knowledge necessary for its solution is immediately available. As every one is aware, a vast amount has been done for popular education in England within the last fifteen years; yet it is precisely the children who have been growing up during the last fifteen years who are furnishing prey for the "Minotaurs" and other scoundrels of the metropolis.

The theory of state education is that the state is bound to see that its juvenile members do not grow up ignorant, and, as a result of ignorance, prone to vice. It is also held that the state owes it to every youthful citizen to furnish him or her with such elements of education as may be needed to fit them for employments requiring a knowledge of reading and writing. From the latter point of view reading and writing are looked upon in the light of tools; but why the state should be required to furnish mental tools rather than material ones—to furnish the child's head with the multiplication-table, but not to provide his hands with saw, axe, or hammer—has never, to our mind, been entirely evident. It seems to us that if the state is to educate, the whole strain and stress of its effort should be to produce good citizens; not to fit this boy for a counting-house or that girl for a position as "sales-lady," but to impart to both that knowledge and imbue both with those principles that make for the right ordering of life and for the good of society. The multiplication-table and the rules of grammar may be found valuable aids to these all-important objects—we do not say they are not—but we insist that they should be looked upon and treated as means always, as ends never; and as means to no other objects than the ones

mentioned. It should be distinctly understood and continually repeated that the state has nothing to do with this or that individual's *success in life*, so far as that may be a matter of competition; that the only "success" the state can undertake to prepare any one for is the success of good conduct and of social adaptation.

Now it is evident that if State education were dominated by this idea, it would have to assume an essentially scientific character. For the conduct of life, what is wanted is not accomplishment of any kind whatever, but knowledge of what life is and a sense of its realities. A true education will, therefore, find its basis in the laws of life—physical, intellectual, and moral—and will aim at bringing each individual face to face with the great realities upon which happiness depends. From such an education all false prudery would be banished. No child would be allowed to grow up in an ignorance which might expose it to the gravest physical perils; on the contrary, the way of physical salvation would be clearly and plainly indicated, and the perils of every kind which wait upon violations of law would be faithfully exhibited. The chief impression, however, would be produced by the constant reference of all instruction to the grand aim of promoting integrity, purity, and harmony of life. Every branch of knowledge would be considered and treated in its bearing upon this aim, and not, as is now generally the case, in its bearing upon individual success in the competition of life. "Do so and so," children are now told, "and you will rise to positions of distinction in society." Yes, provided others fail to act with equal wisdom; but, supposing all to conduct themselves wisely and well, where is the distinction to come from? No doubt it may safely be predicted that all will not; but is it well to assume this in the appeals we make to the young, and so to accustom them to thought of profiting by the errors or weakness of others? The educator, we hold, should use only such modes of appeal as are applicable to all; and a promise of eminence, of distinction, of wealth, of power, is not applicable to all, but only to a few. To all it may be said: "Do so and so, and your life will rest upon solid foundations; you will be a healthful and helpful member of society, and, whatever your lot in life may be, you will have an inward fund of happiness and self-respect that will be secure against all vicissitude. Moreover, the world is so constituted that you can not give without receiving, and whatever you sow for others you will reap the same yourself."

We believe that were education dominated by these ideas, and by the one main purpose we have indicated, the result would soon be seen in quickened intelligences and improved dispositions; and at least the gross ignorance would be removed which at present is answerable for so large an amount of juvenile depravity.

There is, however, another aspect to the question with which we are now specially concerned. What shall be said of the "education" of the men of wealth and leisure, who find their highest pleasure in the most criminal and ruthless forms of vice? These men have passed through public schools, perchance through universities; some are said to be doctors of medicine; others to be eminent at the bar or on the bench; and some even to wear the livery of the Church. In what shape can life have been presented to such men? What sense can they ever have gained of the organic unity of society? What respect can they ever have been taught for the temple of their bodies, or for the cardinal institutes of nature and of society? What regard for others can ever have been inculcated upon them when they think that *money* can atone for the utter degradation of a fellow-creature? Surely it is time to cry aloud and spare not, when men can pass for "educated" to whom the very

elements of a true science of life are unknown, and who, with all their literary, professional, and social acquirements, are willing to descend in their daily practice to the lowest depths of infamy. Think of the two things—"education" and brutal, merciless vice—going hand in hand! Alas! it is not education; it is that wretched, sophistical veneering of accomplishments which usurps the name of education. It may embrace—in the case of medical men must embrace—a certain amount of scientific instruction; but what it lacks is the true scientific grasp of life as a whole. We are no fanatical believers in the saving efficacy of a little smattering, nor even of much special knowledge, of physics and chemistry; but we are firm believers in the moralizing effects of a true philosophy of life, supported and illustrated by constant reference to verifiable facts. All sciences are but parts of one great science, and the highest function of universal science is to teach us how to live. The state, in so far as it undertakes to fit the young for "positions in life," acts upon the old sophistical idea of education as a thing of accomplishments designed to promote individual success. Such education can not of itself have any moralizing effect, and may have a demoralizing. The change that is needed is to abandon that view, and to make education a preparation for life in the broadest sense. Whether the state can adopt the latter principle, and bring its teaching up to the proper level, remains to be seen. If it can not, its condemnation is definitively pronounced, for no other conception of education will meet the requirements of the future.

THE STUDY OF FACTS.

The subject of education has been treated from many points of view, but we do not know that it can be more profitably considered than in its bearing upon the power of recognizing and dealing with facts. The educated man, according to our conception, is he who knows a fact when he sees it and knows what to do with it. The educated man is the man who has an instinct for facts, who searches for them as for hidden treasure, and, having got them, knows how to set them in logical and luminous order. It is the man who knows and feels that facts make up the very backbone of human life and of everything else, and that to ignore them, or to play fast and loose with them, is simply to court failure and loss.

The true *fact* corresponds with the true *idea;* and the man of facts is therefore a man of ideas. He constantly seeks to see the relations of things, and only when he discerns relations does he feel himself to be in the presence of facts. To have an appetite for unrelated facts is as unwholesome as to have an appetite for slate-pencils. "Gradgrind" is not the type of the man of facts: he is rather the type of a man who does not know what a fact is, who is all unconscious that our knowledge in regard to anything has to round itself to some completeness and symmetry before we can claim to possess facts. A true fact is a living, not a dead, thing; and it proves that it is alive by bearing fruit: it produces something, and, like wisdom, it is justified of its children.

What we have in view, however, on the present occasion is, not to pronounce a eulogium on facts—after all, they can take pretty good care of themselves—but to draw attention to the extent to which, in spite of all that has been done for "education," an inability to discern and do justice to facts still prevails in the world. Ask any intelligent business man what the chief trouble is that he encounters among his employés, or what it is that impairs the usefulness of most of them; and he will tell you, not in so many words, but in substance, that it is their imperfect apprehension of facts, and consequent inability to draw conclusions that common sense itself dictates. He will say, perhaps, "Out of a score of men I can only find one

or two who can be trusted to put that and that together." Well, "putting that and that together" simply means mentally recognizing a fact and perceiving its significance. It is not the science of logic that is required in every-day affairs; it is the faculty or habit of seizing main points and holding them as long as may be necessary. The truly superior man, the man who counts, is he who is thus able to take a grip of *things*, of that which is substantial, vital, pertinent, organic.

Self-interest is supposed to be a great sharpener of the mental faculties; but nothing is commoner than to find people ignoring the very facts on which their happiness chiefly depends. They live according to the impulse and humor of the moment, in a kind of disjointed, inconsequent fashion. They do not know the great facts of life; and the truth that their life, as a whole, should present a certain organic unity, and should then itself become a great *fact*, has never been revealed to them. Here is a man who is "all out of sorts." He wants change, he says; the desperate monotony of his existence is killing him. He can not understand how it is that he should have to be always running to the doctor and dosing himself with tonics and alteratives. He likes to throw the blame on circumstances; he likes to think there is something mysterious or at least altogether special in his case; the last thing he wants to hear is that probably his condition is due to the neglect of certain important facts of his physical, perchance, also, of his moral, nature. He willingly lends himself to the nostrums of the quack; but a simple account of the general principles upon which Nature works is nowise to his taste. He does not like to think that certain penalties are irrevocable, or that the only course by which partial relief can be obtained is one of careful submission to law for the future.

We see substantially the same condition of mind in many a man whose business career has been one of failure. He likes to think that success in this world is mainly a matter of accident, and that "luck" was against him. That one word, "luck," is the whole philosophy of some men: it does not explain anything, but it does what is more pleasing to persons of their disposition, enables them to dispense with explanations. We may say in general that there is a fatal disposition in most men not to recognize facts, not to perceive that things are woven together in the iron bands of law, and that nothing stands wholly out of relation to any other thing. This is the tendency which it should be the chief object of education to combat. What we require to do is to build up in the mind, little by little, but with undeviating purpose, the belief that things hang together, and that the business of the intellect is to discover the laws or principles of their association. We should teach that there is order in the universe, which should and must—unless our lives are to be marred by failure—be responded to by a certain order in our thoughts. We should teach on every occasion, and with every possible variety of illustration, that nothing can be done wisely or well that is not done upon system; that random words are vain; that random thoughts are vain; that no mental effort is worth anything that is not dominated by some clear purpose, and that does not connect itself with previously acquired knowledge.

We find ourselves here face to face with the principle of evolution. If evolution means anything, it means the unity of the universe; it means the construction of a path along which thought can travel from the infinitely small to the infinitely great, from forms of the last degree of simplicity to forms of the highest degree of complexity; it means, finally, the blending of subject and object in one all-embracing synthesis. Well, this, according to the measure of our opportunities, is what we have to teach to the young. It will be ac-

knowledged that intelligence is only stimulated by the perception of general truths, or, in other words, of laws, which again are the great *facts* of the universe; but the object in education should distinctly be to show that things only exist in relation to one another, and that things out of relation are virtually *out of existence*. Let a man—to take an illustration—introduce irrelevant matter into his argument: that matter relatively to the object of the argument has no existence. The case is even worse; for, in the place where it is found, such matter is a burden and a nuisance; we must put a minus-sign before it. Now, a teacher who is thoroughly imbued with these ideas, and who neither regards nor accepts anything as *work* that does not show progress in the comprehension of them, will, with an inferior subject, accomplish better results than another man will who, with a superior subject, contents himself with more perfunctory methods. The reason why the teaching of science has so often been comparatively barren is that it has not been broadly taught, and has not, therefore, awakened the true scientific spirit. The reason why language-studies have sometimes appeared to produce superior intellectual results is that they have, in these cases, been taught by earnest men who, by dint of their own extensive culture, have connected these studies with wide areas of literature and history, and so obtained a sufficient field for the illustration of law; in other words, for the presentation of their subject in a scientific manner. *Science*, in the true sense, is vindicated as much by success in the one case as by failure in the other.

This is a matter, it is needless to say, to which too much attention can not be given. The whole progress of society depends upon the intelligence of its members. But intelligence is formed in the earlier years of life; the habit of taking rational views, and of being alive to the teachings of experience, is one which, if not acquired while the intellect is fresh, will probably never be acquired at all. We would therefore urge upon all who are interested in the education of the young to see to it, as far as they possibly can, that by education is understood the development of the habit of seeking the true relations of things, and of conceiving of human life as a network of relations. Let us banish from education the unrelated word, the unrelated thought; let us proceed according to the principle of evolution, linking step with step, while tending always to a higher unity; and the intellectual progress of the race will proceed with all the rapidity that is desirable or possible.

LITERARY NOTICES.

SCIENTIFIC CULTURE AND OTHER ESSAYS. By JOSIAH PARSONS COOKE, LL. D., Professor of Chemistry and Mineralogy in Harvard College. Second edition, with additions. New York: D. Appleton & Co. Pp. 293. Price, $1.

WE had carefully read the first edition of this volume of essays, and have now reread it in its expanded form with renewed pleasure. There are but few scientific writers so trained in the skillful use of English as Professor Cooke. Aside from the value and instructiveness of their contents, his essays are a treat to all who appreciate clearness, vigor, and precision in style, while yet the admirable expression is kept subordinate to intense and weighty thought. The work, however, is to be mainly prized as a contribution to the great educational movement of our time, which aims to give larger recognition to science in our higher schemes of study. This new edition must be taken as representing with a high degree of authority the broad and solid claims of scientific education. It does not deal with the subject technically, or formally, or even systematically, but is simply a collection of essays "written for special occasions without reference to each other," but all having a bearing upon one subject, with which the author has been long occupied both as a philosophic thinker and a prac-

tical teacher. The first essay, "Scientific Culture," and the eleventh, "Scientific Culture; its Spirit, its Aims, and its Methods," present directly the predominant idea of the book; but the various other papers present the view taken in an instructive and impressive manner. The several biographical articles are of extreme interest in illustrating the mental training and development of scientific men; while the papers on the Greek question are designed to meet immediate issues in relation to collegiate reform. The article on "The Elementary Teaching of Physical Science" is of especial value, for, although Professor Cooke has not devoted himself practically to this field of work, his statement of the scientific principles it involves is forcible and timely.

But, while the volume is full of sound suggestions on the general subject of science-teaching, yet its leading title, "Scientific Culture," embodies the fundamental conception which it is designed to bring out; and this is nothing less than an unqualified avowal of the extremest claim put forth in behalf of science as a new educational basis. The adherents of the old traditional system of scholarship are ready enough to admit that there is a certain usefulness and importance in scientific studies, which entitle them to a place in the collegiate curriculum; but they strenuously resist the idea that science is to give rise to a new "culture." Here they make a stand, and here the battle of progressive education is to be fought, with heavy odds, it must be confessed, against the reformers. For "culture" has come to be a very potent word, representing, as it does, all that is most excellent, dignified, and revered in a system of education that has prevailed for centuries in the leading civilized countries. In fact, the chief capital of the classical party to-day, in their struggle against the new education, is the powerful spell of a single term, which has come mainly to imply a critical knowledge of the dead languages, because, by all our scholastic traditions, no man can lay claim to "culture" who is not familiar with Latin and Greek. The term has no doubt become widened in recent times, so as to embrace other languages and the general subject of literature, but the party of tradition is sharply jealous of any extension of it that will make the term "culture" applicable to proficiency in distinctively modern studies.

Professor Cooke takes no narrow view of his subject. He concedes the value of that genuine mental culture, whatever the instruments employed to attain it, which confers intellectual power by the vigorous and systematic exercise of the intellectual faculties; and he recognizes that this may be secured by the thorough study of languages, and the literatures they contain. He draws a distinction between erudition and scholarship, the former implying the simple accumulation of stores of learning, and the latter a discipline of the intellect and an enlargement of mental power through the process of independent inquiry. The same thing holds in science. The cramming of books—the erudition of science—is of but little worth; while the independent exercise of the mind upon the problems of science—the assimilation of acquisitions into a real knowledge—is the true scholarship of science, and the highest form of mental cultivation. Professor Cooke shows conclusively that the "culture" of science is a broader conception, and involves a more varied and a completer mental training, than can be obtained from the exclusive study of language and of literature, because science has for its object the study of nature, and the whole scheme of phenomena and law in the midst of which human life is carried on.

THE RELIGIOUS ASPECT OF PHILOSOPHY: A Critique of the Bases of Conduct and of Faith. By JOSIAH ROYCE, Ph. D., Instructor in Philosophy in Harvard College. Boston: Houghton, Mifflin & Co. Pp. 484. Price, $2.

IF the test of a system of philosophy is, as Ferrier says, that it must be "reasoned," then is Dr. Royce's work entitled to this rank, for it is undoubtedly an ably "reasoned" system. He has written an independent and suggestive book, lively and vigorous in style, and which is certain to be appreciated by those who have a taste for metaphysical inquiries.

In his preface the author describes the work better than we can: "This book sketches the basis of a system of philosophy, while applying the principles of this sys-

tem to religious problems. The form and order of the treatment depend upon the nature of these latter problems themselves, and are not such as a system of philosophy, expounded solely for its own sake, would be free to take. The religious problems have been chosen for the present study because they first drove the author to philosophy, and because they, of all human interests, deserve our best efforts and our utmost loyalty."

It seems, therefore, that our author was driven to philosophy by some sort of religious disquiet or perplexity. We gather from what follows that he had lost his faith, or was fearful of losing it, and went to philosophy for relief. What he found it is the office of the book to tell, but it is evidently something very different from that which had left him at first. He says: "As he has no present connection with any visible religious body, and no sort of desire for any such connection, he can not be expected to write an apology for a popular creed. This confession is made frankly, but not for the sake of provoking a quarrel, and with all due reverence for the faith of other men. If the fox who had lost his tail was foolish to be proud of his loss, he would have been yet more foolish to hide it by wearing a false tail, stolen mayhap from a dead fox. The full application of the moral of the fable to the present case is, moreover, willingly accepted. Not as the fox invited his friends to imitate his loss, would the present writer aim to make other men lose their faiths. Rather is it his aim not to arouse fruitless quarrels, but to come to some peaceful understanding with his fellows touching the ultimate meaning and value and foundation of this noteworthy custom, so widely prevalent among us, the custom of having a religion."

Nevertheless, the philosophy he sought seems to have answered the author's purpose, as it showed him that the skepticism he dreaded was not so bad a thing after all. Again he says: "As to the relation of this book to what is called modern doubt, it is a relation neither to blind obedience nor of unsympathetic rejection. The doctrine of philosophic idealism here propounded is not what in these days is popularly called agnosticism. Yet doubting everything is once for all a necessary element in the organism of philosophic reflection. What is here dwelt upon over and over again is, however, the consideration that the doubts of our time are not to be apologetically 'refuted,' in the old-fashioned sense, but that, taken just as they are, fully and cordially received, they are upon analysis found to contain and imply a positive and important religious creed, bearing both upon conduct and upon reality. Not to have once thoroughly accepted as necessary the great philosophic doubts and problems of our day, is simply not to have philosophized as a man of this age. But to have accepted these doubts without in time coming to accept the positive truth that is concealed in them, is to treat them as the innocent favorite of fortune in a fairy tale always at first treats his magic gift. It is something common and dingy, and he lays it carelessly away in his empty house, feeling poorer than ever. But see: handle it rightly, and the fairy gift fills your transfigured home with a wealth of gems and gold, and spreads for you a wondrous banquet. To the author has come the fancy that modern doubt may be some such fairy gift as this, and he would like to suggest to some reader what may possibly prove the right fashion of using the talisman."

More light is thrown upon the author's position by a passage from his introductory chapter, where he remarks: "The short and easy agnostic method is not enough—you must supplement skepticism by philosophy; and when you do so, you will find yourself forced to accept, not indeed the old theology of your childhood, but something that satisfies oddly enough certain religious longings that, as skeptic, you had carefully tried to forget. Then you'll find yourself with what you may have to call a religious doctrine; and then you may have to state it as we are here going to do, not in an easy or fascinating way, such as the pure skeptic can so well follow, but at all events with some approach to a serious and sustained effort to consider hard questions from many sides. The skeptical method is not only a good but also a necessary beginning of religious philosophy. But we are bound to go deeper than mere superficial agnosticism."

From these quotations the reader will be able to form some tolerable conception

of the scope and purpose of Dr. Royce's work. Of its value as a contribution to speculative thought we are not qualified to speak. But, turning to Chapter I, in which the author puts the grave question, "What, then, is religion?" we do not find the answer so clear and satisfactory as seems required in stating the fundamental idea of a religio-philosophical system. Religion, according to our author, is something important, vaguely associated with ethics. He says: "So much, at all events, seems sure about religion. It has to do with action. It is impossible without some appearance of moral purpose." Again: "A religion adds something to the moral code, and what it adds is, first, enthusiasm." And again: "But in fact religion always adds another element. Not only does religion teach devotion to a moral code, but the means that it uses to this end include a more or less complex theory of things. Religion says not merely, *do* and *feel*, but also *believe*. . . . These three elements then go to constitute any religion." On this basis, which is at any rate sufficiently comprehensive, and by the help of the great lights of German philosophy—Kant, Hegel, Schopenhauer, Lotze, and others—Dr. Royce builds his system, and in the opinion of able critics he has built to excellent purpose.

THE FRENCH REVOLUTION. By HIPPOLYTE ADOLPHE TAINE. Translated by John Durand. Vol. III. New York: Henry Holt & Co. Pp. 509. Price, $2.50.

THE present volume gives the history of the revolutionary government, including the Reign of Terror. The author expresses himself in his preface as regarding the leaders in the movements of the time in the same light as he would the crocodiles of the ancient Egyptian temples—dangerous animals, brutes rolling about on a purple carpet, but worshiped in their day. Of his own kinds of "crocodiles" he has studied the details of the structure, the play of the organs, their habits, their modes of living, their faculties, and their appetites. Of the thousands of specimens he had at hand, he has selected a few for special treatment, of which the three largest seem, "of their kind, truly remarkable, and those in which the divinity of the day might well incarnate himself. The bills of butchers, as well as housekeeping accounts, authentic and regularly kept, throw sufficient light on the cost of this cult. We can estimate how much the sacred crocodiles consumed in ten years, we know their bills of fare daily, their favorite morsels. Naturally, the god selected the fattest victims, but his voracity was so great that he likewise bolted down, and blindly, the lean ones, and in much greater number than the fattest. Moreover, by virtue of his instincts, and an unfailing effect of the situation, he ate his equals once or twice a year, except when they succeeded in eating him. This cult certainly is instructive, at least to historians and men of pure science." We are told also that "this volume, like the others that have gone before it, is written solely for amateurs of moral zoölogy, for naturalists of the understanding, for seekers of texts and of proofs—for these and not for the public, whose mind is made up, and which has its own opinion on the Revolution."

THE MORALS OF CHRIST. By AUSTIN BIERBOWER. Chicago; Colegrove Book Company. Pp. 200. Price, 50 cents.

"IN announcing his morality," says the author, "Christ took three departures from other systems—one from the Mosaic, one from the Pharisaic, and one from the Græco-Roman. . . . In departing from the Mosaic morality, he sought to develop morality from its primitive rudeness and simplicity; in departing from the Pharisaic morality, he sought to recall it from a ritualistic divergence to the proper subjects of morality; and, in departing from the Græco-Roman morality, he sought to substitute the tender for the heroic virtues." The author's purpose in this essay is declared to be to set forth the morality of Christ as a departure from these three representative types, "it being this triple departure, more than anything absolute, on which he put his chief emphasis, and which, more than anything original, characterized his system."

THE HISTORY OF THE PRESENT TARIFF. 1860–1883. By F. W. TAUSSIG. New York: G. P. Putnam's Sons, Pp. 111. Price, 75 cents.

THIS volume is intended to give a narrative of the growth of the protective sys-

tem which now exists in the United States. It endeavors to state the circumstances under which the various tariff acts were passed, the causes which made their enactment possible, and the changes of duty which they brought about—facts which may be familiar enough to old citizens who have not shut their eyes to them, but which can hardly be known to the younger Americans who have been taught that the protective policy is an essential part of our institutions and prosperity. The author has opinions of his own on the subject, which he has not concealed, but which he has tried not to allow to distort his statements of facts.

THE HISTORY OF THE SURPLUS REVENUE OF 1837. By EDWARD G. BOURNE. New York and London: G. P. Putnam's Sons. Pp. 161. Price, $1.25.

THE proposition has been made within the past two years, instead of reducing our revenue, now too large for the legitimate needs of the Government, to continue collecting the surplus to form a fund for distribution among the States. A similar experiment was tried once before in the history of our country, with disastrous results; but men's memories are short in political and financial history, and the story has been forgotten except by students. Mr. Bourne's book appears opportunely to bring the lesson back to mind, and warn such persons as need the warning and would heed it. In the main it is a relation of facts, showing how the surplus was disposed of in the several States which shared in the distribution, and what came of the dispositions.

PROCEEDINGS OF THE COLORADO SCIENTIFIC SOCIETY. Vol. I, 1883 and 1884. Denver: Published by the Society, Whitman Cross, Secretary. Pp. 147, with Plate.

THE Colorado Scientific Society was formed in December, 1882, "for the promotion of scientific intercourse, observation, and record in the State of Colorado." From the twelve original members it increased during the first year to a body of thirty-one members. The contents of the present volume of its proceedings are well described by Mr. S. F. Emmons, its first year's president, in his retiring address, as "interesting and instructive papers upon new methods in the chemical investigation of metals; on the geology and manner of occurrence of ores in Colorado mining districts, and the discovery of minerals not only new in this part of the world, but some new to science; upon glacial phenomena in Colorado; upon the geology and volcanic phenomena of the far-distant Dutch possessions in the East Indies; and suggestions with regard to the home question of the supply of water from artesian wells to be expected in Denver."

THE MUSEUM, Vol. I, Nos. 1 and 2, May and June, 1885. Philadelphia: William F. Fell & Co. Pp. 16 each number. Price, 15 cents; $1.50 a year.

THE "Museum" is an illustrated monthly journal for collectors of all classes and young naturalists. The numbers before us bear the marks of good editing and efforts to secure original contributions from men whose names carry authority in their respective departments of research.

SYMBOLISM AND SCIENCE. By LLOYD P. SMITH. Philadelphia: Privately printed. Pp. 23.

THIS essay was originally read as a paper before the Germantown Science and Art Club. The author's purpose was to call attention, "rather by way of suggestion than otherwise," to the subject of the esoteric or symbolical method of teaching pursued originally in the East, and the pernicious effects it has had on the progress of true knowledge even down to our own time.

LESSONS IN HYGIENE. By JOHN C. CUTTER, M. D. Philadelphia: J. B. Lippincott Company. Pp. 180. Price, 50 cents.

THIS is an elementary text-book, adapted for common schools, on the maintenance of health, with the rudiments of anatomy and physiology, and the treatment of emergent cases, and lessons on the action of stimulants and sedatives on the brain and nervous system. It presents the essential facts concerning bathing, clothing, air, water, food, cooking, home-construction, mental work, physical exercise, eye-work, contagious disease, filth-disease, disinfection, tea, tobacco, chloral, alcoholics, etc., as bearing upon the maintenance of health and the prevention of disease. The practical is prominent throughout.

CHRISTIAN THOUGHT. Second Series. Edited by CHARLES F. DEEMS, LL. D., President of the American Institute of Christian Philosophy. New York: Phillips & Sons, 80 Fourth Avenue. Pp. 476.

THE "Institute of Christian Philosophy" is a society which holds stated meetings for the discussion of questions bearing upon the relations of science and the Christian religion, together with annual assemblies on the Chautauqua plan at some place of summer resort, where the same questions are formally considered with carefully prepared addresses before as large audiences as will attend. The present volume represents the sum of the year's work of the institution as embodied in the more important lectures and papers on philosophy, Christian evidence, and biblical elucidation, spoken at the monthly and annual meetings. These, as they appeared in the monthly numbers of the periodical "Christian Thought," were varied with editorial remarks, briefer articles, paragraphs, and squibs, all having some bearing on the main question, which are also incorporated in the volume.

AN ACCOUNT OF THE PROGRESS IN ZOÖLOGY IN THE YEAR 1883. By THEODORE GILL. Washington: Government Printing-Office. Pp. 53.

THOUGH no startling discoveries in zoology were recorded during 1883, the progress of the science was real. The two important events deemed worthy of special notice were the International Fisheries Exhibition in London, and the publication of Jordan and Gilbert's "Synopsis of the Fishes of North America." Mr. Gill's "account" is composed of synopses of the several papers and reports of the investigations of naturalists in the various countries in which science is systematically pursued.

ARCHÆOLOGICAL INSTITUTE OF AMERICA. Sixth Annual Report, 1884–'85. Cambridge, Mass.: John Wilson & Son. Pp. 48.

A NEW departure has been taken by the institute, in order to give it wider national scope and interest, in the division into affiliated societies, of which there are now three, those of Boston, Baltimore, and New York, each with its own roll of members and set of officers. Progress is reported in the exploration of New Mexico and Arizona by M. Bandelier, in the collation of the results of the excavations at Assos, Asia Minor, and in the publication of papers. An expedition was sent out last fall to Babylonia, under the charge of Dr. W. Hayes Ward, for the purpose of looking over the field and finding a favorable site for future thorough investigation. It has not yet made a report for publication. The institute collected and expended $46,150 between May, 1879, and May, 1885.

PROCEEDINGS OF THE MODERN LANGUAGE ASSOCIATION OF AMERICA, 1884, Professor A. M. ELLIOTT, Baltimore, Md., Secretary. Pp. 100.

THE "Modern Language Association" was organized in the city of New York in December, 1883. Its object is the "advancement of the study of the modern languages and their literatures." The second meeting, of which this pamphlet contains the report, was held at Columbia College, New York, on the 29th and 30th of December last. A considerable number of papers, abstracts of which are here given, all instructive and suggestive, were read, bearing on the value of modern languages, the desirability of giving more attention to them and of putting them on an equal footing with the ancient languages, and the best methods of teaching them. A resolution was adopted expressing the opinion of the convention that the establishment of a classical course in modern languages, with special view to disciplinary methods, alongside the ancient classical course in our colleges is not only desirable but practicable.

NOTES ON THE LITERATURE OF EXPLOSIVES. By Professor CHARLES E. MUNROE, U. S. N. A., Annapolis, Md. Pp. 32.

THE title well describes the scope of the book. It is a collection of "notes," derived from various sources, covering the chief points of interest concerning explosives, their manufacture, the preparation and application of new ones, their use, and the precautions observed in their manufacture and transportation. It is a continuous publication, appearing in installments from time to time, as new information is brought to light and collected by the compiler.

ELEPHANT PIPES IN THE MUSEUM OF THE ACADEMY OF NATURAL SCIENCES, DAVENPORT, IOWA. By CHARLES E. PUTNAM. Pp. 40.

THE Academy of Natural Sciences of Davenport has two pipes in the shape of elephants, and three inscribed tablets, which are claimed to have been found among aboriginal relics. Their genuineness has been doubted by some, and has been attacked by Mr. Henry W. Henshaw, in the report of the Bureau of Ethnology. This essay is a vindication of their authenticity by a member of the academy. Behind the question immediately at issue lies the controversy respecting the origin of the mound-builders, on which archæologists are dividing.

MUSHROOMS OF AMERICA, EDIBLE AND POISONOUS. Edited by JULIUS A. PALMER, Sr. Boston: L. Prang & Co. Pp. 4 of Text, with Twelve Chromo-lithographic Plates.

REGARDING the edible mushrooms as supplying most valuable and delicious food, the author seeks to furnish a guide in the selection of species that shall admit of no mistake being made. The letterpress pages furnish general directions for recognizing and gathering the useful species and avoiding the dangerous ones; and the plates give exact portraits of both kinds, in their natural sizes and colors, with botanical descriptions, and directions for preparing them for the table. The same information is given in a cheaper form in two charts, one containing the useful, the other the dangerous kinds. Mr. Palmer's qualifications for the description of these plants are attested by the fact that he has for more than ten years directed his attention and experiments to ascertaining the edible or noxious qualities of the various species of mushrooms abounding in our fields and woods.

A COURSE OF PRACTICAL INSTRUCTION IN BOTANY. By F. O. BOWER and SIDNEY H. VINES. London: Macmillan & Co. Pp. 226. Price, $1.50.

THIS work has grown out of the course of botanical instruction which was begun in 1873 by Mr. W. Thistleton Dyer in the Normal School of Science at South Kensington, in which the same plan was adopted as Professor Huxley had found convenient for the animal side of morphology. Mr. Dyer's purpose, to put the results of his experience in teaching methods in the form of a hand-book, which he has not been able personally to carry out, has been fulfilled by his successor, Mr. Bower, in the matter of laboratory instruction for the types selected, and by Dr. Vines in the matter of method and the morphology of the cells. The plan of the teaching is—typical specimens having been selected of well-known or easily identified plants—to give the pupil directions for making careful and minute examinations of all their parts, their structure, and their visible qualities. This volume, which is designated as Part I, is devoted to the phanerogams and the pteridophyta.

THE BASIC PATHOLOGY AND SPECIFIC TREATMENT OF DIPHTHERIA, TYPHOID, ZYMOTIC, SEPTIC, SCORBUTIC, AND PUTRESCENT DISEASES GENERALLY. By GEORGE J. ZIEGLER, M. D. Philadelphia: George J. Ziegler, M. D. Pp. 225. Price, $2.

THE author's treatise is based upon and unfolds the theory that the diseases in question are "dependent upon, or complicated with, one common basic, alkaline, pathogenic factor, mostly the volatile alkali ammonia, incidental to all forms of life, and differing only in quantity and the constitutional and local manifestations and complications arising from diverse etiological and pathological conditions, yet underlying and intensifying them all."

A MANUAL OF THE THEORY AND PRACTICE OF TOPOGRAPHICAL SURVEYING BY MEANS OF THE TRANSIT AND STADIA. By J. B. JOHNSON, C. E. New York: John Wiley & Sons. Pp. 113. Price, $1.25.

THE author is Professor of Civil Engineering in Washington University, and was formerly Engineer of the United States Lake and Mississippi River Surveys. The system which he explains is well adapted to preliminary railroad and canal surveys; surveys of drainage-basins, reservoir, dam, and bridge sites; the location of ditches and pipe-lines; and, in fact, to surveys of any kind demanding a knowledge of the topographical features or of the contours of the ground. He has had, as objects in view in preparing the work, to make a manual useful to students and in the work in the

field; to explain the methods of field-work so clearly and minutely that an engineer in practice could, without other instruction, prepare his instruments, and do the work in good shape; and to furnish means of reducing the field-notes and methods of plotting, the results of many years' experience of many engineers.

THE LINEAL MEASURES OF THE SEMI-CIVILIZED NATIONS OF MEXICO AND CENTRAL AMERICA. By DANIEL G. BRINTON, M. D. Philadelphia. Pp. 14.

DR. BRINTON is devoted to the study of the history and civilization of the aborigines of the Americas, and pursues it with industry in all its branches. In the present monograph he gives the results of his analyses of the words for weights and measures in the Maya, Cakchiquel, and Nahuatl or Aztec languages, instituted to ascertain, if possible, what units, if any, were employed by the peoples who spoke them. The measures of these nations seem to have been derived from the body, and some of them were curious. A unit of land-measure among the Cakchiquels was the circumference of the human figure. A man stood erect, his feet together, and both arms extended. The end of a rope was placed under his feet and its slack placed over one hand, then on top of his head, then over the other hand, and was finally brought to touch the beginning. This gave somewhat less than three times the height. The Aztecs had four measures from the point of the elbow: one to the wrist of the same arm, a second to the wrist of the opposite arm, a third to the ends of the fingers of the same arm, and the fourth to the ends of the fingers of the opposite arm. Neither of the three nations was acquainted with a system of estimation by weight, or with the use of the plumb-line, nor with an accurate measure of long distances.

THE MAGNETISM OF IRON AND STEEL SHIPS. An Explanation of the Various Ways in which it affects the Compass. By T. A. LYONS. Washington: Government Printing-Office. Pp. 124, with Plates.

THIS volume is the seventeenth of the series of "Naval Professional Papers." Its purpose is to exhibit in a concise form the principal phenomena of the deviations of the compass on iron ships. First are described the characteristics of a steel magnet, the method of determining those characteristics for any particular one, and the reciprocal action of two magnets. Next, the similitude of the magnetism in an iron or steel ship to that of an ordinary bar magnet is established, and the inquiry is made applicable to the ship, whereby we may become acquainted with her magnetic peculiarities. These observations are complemented by a number of experiments, all helping to complete the investigation, and to bring out a more satisfactory elucidation of the subject.

THE RELIGION OF PHILOSOPHY; OR, THE UNIFICATION OF KNOWLEDGE. A Comparison of the Chief Philosophical and Religious Systems of the World, made with a View to reducing the Categories of Thought, or the most General Terms of Existence, to a Single Principle, thereby establishing a True Conception of God. By RAYMOND S. PERRIN. New York: G. P. Putnam's Sons. Pp. 566. Price, $4.

THE purpose and character of this elaborate volume are admirably summed up in its comprehensive title-page. The author has taken to metaphysics from the most modern point of view, and labored with great assiduity, much learning, and no little analytic and constructive skill, to work out the grand conception of unity in the world of philosophical thought. Firmly accepting that important principle of science, that the fewer assumptions we make in the explanation of things the better, he has labored to reduce the number of principles hitherto postulated as the primary elements of existence, and to show that there is but one final and universal principle, of which all others are but derivative expressions. Part I, consisting of eight chapters, is an epitome of the history of philosophy from the dawn of speculation among the Greeks down to the eclecticism and positive philosophy of France and the Scotch school. The contributions of the most illustrious philosophers embraced in that long period are sifted and estimated with a view to their bearings upon the fundamental proposition which the author finds himself called upon to establish. Part II consists of eight chapters, devoted to "The Nature of Perception," four of which are given to Herbert Spencer and four to G. H.

Lewes. In Part III we reach the subject indicated by the title of the book, "The Religion of Philosophy." We have here eight further chapters, six of which are devoted to an account of the leading religious systems of the world, with reference to the fundamental thesis of the author's book. The seventh of these considers "The Science of Morality," and the last is an "Appeal to the Women of America in Behalf of the Religion of Philosophy."

We can do no more than give this brief outline of a portly book which has cost the author immense labor, and will, no doubt, prove helpful to students interested in the various questions it discusses. Of the validity of the work as an original contribution to philosophic thought we can not speak, as we have not had time to give it critical attention. Appealing to the scholarship of the time, it must abide its verdict on the claims of the performance to live in the future.

PROCEEDINGS OF THE BIOLOGICAL SOCIETY OF WASHINGTON. Vol. II, July 1, 1882, to July 1, 1884. Washington: Smithsonian Institution. Pp. 127.

THE volume contains, with lists of members, etc., abstracts of the proceedings of the stated meetings of the society, and mention by name of the papers read at each, two presidential addresses, and sixteen special papers. The presidential address of Mr. Theodore Gill, January 19, 1883, was on "Zoögeography," and gave an elaborate review of the faunal regions or "realms" into which naturalists have divided the earth. The presidential address of Mr. Charles A. White, January 25, 1884, was on "Certain Phases in the Geological History of the North American Continent, biologically considered."

SANITARY SUGGESTIONS ON HOW TO DISINFECT OUR HOMES. By B. W. PALMER, M. D. Detroit, Mich.: George S. Davis. Pp. 58. Price, 25 cents.

THIS is a handbook for popular perusal, containing the latest and best information on the household use of disinfectants, deodorants, and antiseptics, and practical precautions for the prevention of cholera, diphtheria, scarlet fever, and other infectious diseases.

THE FILTH POWER. By J. B. OLCOTT. Pp. 41.

THIS is a paper from the report of the Secretary of the Connecticut Board of Agriculture, having been made originally, apparently, in the form of an address at one of the meetings of the board. Its purpose is to present the system of removal of sewage by water as the great evil that now threatens the health and morals of our communities. Sewage irrigation is also condemned as an evil hardly, if any, less dangerous. Making allowance for the speaker's great intensity of statement, there can be no doubt that a truth is here held up to view. Pollution of streams and the ground by turning the nastiness of towns upon them is a dire evil, which, threatening to become almost universal, can not be combated and remedied too soon. For a remedy, the author proposes systematic treatment of all refuse matter with earth.

MIND IN NATURE. Vol. I, Nos. 1 and 3. March and May, 1885. Chicago: Cosmic Publishing Company. Monthly. Pp. 16 each number. Price, 10 cents a number, $1 a year.

THIS is a popular journal of "Psychical, Medical, and Scientific Information," and gives especial attention to what has come to be called "Psychical Research." It has a large list of special contributors, among whom clergymen and students of the nervous system are well represented.

REMARKS UPON CHIPPED STONE IMPLEMENTS. By F. W. PUTNAM. Salem, Mass.: Salem Press. Pp. 8, with Nine Plates.

THE "remarks" were made at a meeting of the Essex Institute, and relate to the method of manufacture, the character, and use of the implements in question. The plates represent various implements, with and without handles, from Trenton, New Jersey, Mexican localities, the Navajo and Pah-Ute Indians, and Tierra del Fuego.

FACTS SERVING TO PROVE THE CONTAGIOUSNESS OF TUBERCULOSIS. By W. H. WEBB, M. D. Philadelphia. Pp. 28.

THE author cites a number of cases that occurred in his own practice where a wife appeared to contract consumption from her husband, and husbands from their wives, and refers to many other cases of which he

has notes which prove, he says, "conclusively," the contagiousness of phthisis. He also publishes a note from Surgeon-General von Lauer, of the Royal Prussian War Department, supporting the same view, and describes his apparatus for catching tubercle-bacilli in the air near victims of tuberculosis, and some of the results of using it.

FOUL BROOD: ITS MANAGEMENT AND CURE. By D. A. JONES. Beeton, Ont.: "Canadian Bee Journal." Pp. 24.

"FOUL BROOD" is a disease of bees, which, in order that the treatment may not be misapplied, the author carefully distinguishes from "chilled," "neglected," "overheated," "drowned," and "dead" brood. It is a germ-disease, and lurks in the honey, whence the bees contract it. The author's remedy is to cause the bees to fast till all the diseased honey is eliminated from their systems. The process has to be very carefully performed, and the cautions to be observed are particularly insisted upon in the directions.

BULLETINS OF THE UNITED STATES GEOLOGICAL SURVEY. No. 2, pp. 8; No. 3, pp. 36; No. 4, pp. 34, with Nine Plates; No. 5, pp. 325; No. 6, pp. 43; No. 11, pp. 66, with Six Plates. Washington: Government Printing-Office.

THE bulletins are numbered in a continuous series, and will be bound in volumes of convenient size. The first six numbers constitute Vol. I, which will contain 493 pages, with eleven plates. Of the present list, No. 2 consists of "Gold and Silver Conversion Tables," which give the coining values of troy ounces of fine metal, and the weights of fine metal represented by given sums of United States money. In No. 3 are described the fossil faunas of the Upper Devonian along the meridian of 76° 30′, from Tompkins County, New York, to Bradford County, Pennsylvania. Number 4 gives accounts by Charles A. White of mesozoic fossils, including descriptions of certain aberrant forms of the *Chamidæ* from the cretaceous rocks of Texas; of a small collection gathered in Alaska by Mr. W. H. Dall; and of the Nautiloid genus *Enclimatoceras Hyatt.* No. 5 is a "Dictionary of Altitudes" in the United States, arranged by States and alphabetically by places, compiled by Mr. Henry Gannett. The data are derived from special, railroad, State, and municipal surveys, and generally from barometric or trigonometrical determinations. No. 6 is a list of elevations in the Dominion of Canada, derived generally from railroad and canal surveys. No. 11 is a paper on the quaternary and recent mollusca of the Great Basin, with descriptions of new forms, by R. Ellsworth Call, for which an introductory sketch of the quaternary lakes of the Great Basin is furnished by Mr. G. K. Gilbert.

ETHICAL CULTURE. Four Lectures. By SAMUEL BURNS WESTON. Philadelphia. Pp. 70. Price, 20 cents.

THE Society for Ethical Culture, whose views are partly set forth in these lectures, regards the moral reason as the soul's sovereign authority, and holds that in yielding obedience to that authority, in living true to the dictates of our moral and rational nature, we are on the path that leads to the heights of religion. The present lectures were delivered to the society in Philadelphia. The special subjects are: "The Need of an Ethical Religion"; "Why Christianity does not satisfy us"; "The Success and Failure of Liberalism"; and "The Meaning of a Society for Ethical Culture."

THE SANITARY MONITOR. A Monthly Journal. Vol. I, Nos. 1 and 2, May and June, 1885. J. F. WINN, M.D., Editor and Proprietor. Pp. 14 each number. Price, 10 cents; $1 a year.

THE "Monitor" is devoted to "Individual, Family, and Public Health," and gives contributions, addresses, editorial articles, reports, and items bearing upon these important subjects. It is not a medical journal, but is designed especially for the instruction of the laity in matters pertaining to the preservation of health.

ARCHITECTURAL STUDIES. PART I. TWELVE DESIGNS FOR LOW-COST HOUSES. New York: William T. Comstock, 6 Astor Place. Price, $1.

THE designs are shown on a large scale, with full details, and include prize designs from "building competition," with specifications, bills of materials, and estimates of cost. The costs of the buildings are estimated at $2,600 and less.

THE ABDOMINAL BRAIN. By LEILA G. BEDELL, M. D. Chicago: Gross & Delbridge. Pp. 45.

THE name of the book is taken from Bichat, who first used the term. The purpose is to maintain that not the brain and spinal cord alone, but the whole nervous system, particularly that part of it called the sympathetic, is concerned in the operations of mind. The author refers, in her introduction, to a paper by Dr. W. A. Hammond, which was published in "The Popular Science Monthly" after her essay was read in her society, the "Woman's Physiological Institute of Chicago," as bearing on her subject, and indicating that there is a place in science for her views.

A NEW PHILOLOGICAL THEORY. By Professor A. J. MOGYOROSI. Alleghany, N. Y. Pp. 11.

PROFESSOR MOGYOROSI believes that those writers on languages are wrong who regard the Aryan and Shemitic families as presenting the most perfect types of structure, and ignore the Turanian family, which is, he suggests, to the others as the center to the right and left wings. He illustrates his position by several examples of word-roots as they appear in the several families, in which the Magyar serves as the type of the Turanian.

PUBLICATIONS RECEIVED.

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Notes on the Literature of Explosives. No. VIII. By Professor Charles E. Munroe, U. S. Naval Academy, Annapolis, Md. Pp. 18.

The Soaring Birds. A Mechanical Problem. By I. Lancaster. Chicago. Pp. 22.

Woman, a Poem. By Logan E. Bleckley. Clarksville, Ga. Pp. 23.

A Study of Thermometers, etc. By O. T. Sherman. Pp. 4.

A Plea for the Medicinal Use of Pure Alcohol, etc. By Henry Leffmann, M. D. Philadelphia. Pp. 10.

The Spirit of Scientific Progress. By Harvey W. Wiley, Ph. D. Pp. 20.

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Crop Report (Georgia) for July, 1885. J. T. Henderson, Commissioner of Agriculture, Atlanta. Pp. 23.

International Electrical Exhibition (Philadelphia) Reports. Carbons for Arc Lamps. Pp. 16. Steam-Boilers. Pp. 39. General Report of the Chairman of the Committee on Exhibitions. Pp. 54.

The Western Society for Psychical Research. Chicago. Constitution and Rules. Pp. 8.

The Terraces of Rotomahana, a Poem. By Frank Cowan. To which is prefixed a Paper on Geyser Eruptions and Terrace Formations. By Josiah Martin, F. G. S. Auckland, N. Z. Pp. 61.

Marginal Kames. By H. Carvill Lewis. Philadelphia. Pp. 26.

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Hydatid Tumors in the Brain. By R. Harvey Reed, M. D. Mansfield, Ohio. Pp. 16.

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POPULAR MISCELLANY.

Industrial Education in Common Schools.—Mr. B. B. Huntoon recently read a paper before the "Conversation Club" of Louisville, Kentucky, on "Industrial Education," in which he advocated the introduction of the Russian system into the public schools. This system does not aim to teach the practical exercise of particular arts, but only so to train the eye and hand to the execution of designs and the use of tools that the pupil may be qualified to take up readily whatever art he may afterward choose to follow. The system, in its most essential features, has already been tried successfully in the Massachusetts Institute of Technology; Washington University, at St. Louis; Purdue University; Illinois University; Tulane University, New Orleans; and in industrial schools in Chicago, Baltimore, Philadelphia, and New York city; and in Boston and Gloucester, Massachusetts, and Montclair, New Jersey, the experiment has been tried of incorporating a course of industrial training upon the city schools. Mr. Huntoon believes that the people are ready to be taxed for such a purpose; that there will be no difficulty in finding teachers; and that the scheme is entirely practicable.

The Pittsburg Natural Gas-Wells.—According to the account recently given by Mr. Andrew Carnegie to the Iron and Steel Institute, the principal district in which the natural gas-wells near Pittsburg are found, the Murraysville field, lies to the northeast of that city, running southward from it toward the Pennsylvania Railroad. Nine wells had been sunk there last fall, and were yielding gas in large quantities. Gas has been found in a belt averaging about half a mile in width for a distance of between four and five miles. Beyond this a point is reached where salt-water flows into the wells and drowns the gas. The gas-fields of Washington County are about twenty miles from the city, swinging round toward the southwest. Four wells are now yielding gas in this district, but are not, perhaps, so strongly charged as those of the Murraysville district, and others are being drilled. Still farther to the west is another gas territory, from which manufacturing works in Beaver Falls and Rochester receive their supply. Next is the Butler gas-field, as far from Pittsburg on the northwest as are the Washington County wells on the southwest. Next, on the Allegheny River, is the Tarentum district, still about twenty miles from Pittsburg, which is supplying a considerable portion of the gas used. Thus, within a circle around Pittsburg having a radius of fifteen or twenty miles, there are four distinct gas-producing districts. Several wells have been bored within the city; but, though they all yielded gas, it has been drowned out by the rush of salt-water. While the largest well known yields about 30,000,000 cubic feet of gas in twenty-four hours, the average product of a good well may be set at about

half of this. The pressure of the gas as it issues at the mouth of the well is nearly or quite two hundred pounds per square inch. Even at the works of the company represented by Mr. Carnegie, nine miles from the well, the pressure is seventy-five pounds per square inch. Eleven lines of pipe are conveying gas from the various wells to the manufacturing establishments in and around Pittsburg. Although it is only two years since gas has been used in Pittsburg, it has already displaced 40,000 bushels of coal per day in the mills that have used it, and about an equal amount has been displaced in the works beyond the city limits. Contracts are now made to supply houses with gas at a cost equal to that of the coal bill for the preceding year. In many houses, no other fuel than this gas is used; and everybody who has applied it to domestic purposes is delighted with the change from the smoky and dirty bituminous coal. It is, therefore, Mr. Carnegie suggests, quite within the region of probability that the city, now so black, may become so revolutionized as to be the cleanest manufacturing city in the world.

English Board-School Science.—Dr. Andrew Wilson's "Health" has been struck with some of the answers in the school-children's examination-papers in popular science, and gives a few specimens of them. Among them are—"the humerus (or upper arm-bone) is known as the 'humerous,' and is often called 'the funny-bone.'" "The sweet-bread is otherwise called the pancras (for pancreas), which is so named from the Midland Railway Station in London." "A thermometer is an instrument used to let out the heat when it is going to be cold." "When roasting a piece of beef, put it in front of a brisk fire, so as to congratulate the outside." "Sugar is an amyloid. If you were to eat much sugar and nothing else, you would not live, because sugar has not got no carbon, hydrogen, oxygen, nitrogen. Potatoes is another amyloids." Very interesting is the description of digestion given by one of the pupils: "Food is digested by the action of the lungs; digestion is brought on by the lungs having something the matter with them. The food then passes through your windpipe into the pores, and thus passes off you by evaporation, through a lot of little holes in your skin called capillaries. The food is nourished in the stomach. If you were to eat anything hard you would not be able to digest it, and the consequence would be you would have indigestion. The gall-bladder throws off juice from the food which passes through it. We call the kidneys the bread-basket, because it is where all the bread goes to. They lay concealed up by the heart."

A Story of Two Rats.—A correspondent of "Land and Water" tells a story of two white rats which he had adopted as pets. The male was a quiet, commonplace sort of rat, acquaintance with whom afforded few incidents of particular interest. The female was a great coquette, and a regular domestic tyrant, exercising absolute control of her spouse and household. Always pleased with the gift of some dainty, she was "rapturously delighted" if allowed to think she had stolen it. If the master would have a piece of sugar on the table, she would creep up and take it, retreating behind a book to devour it, as she hoped, unobserved. She was a relentless enemy to mice; and, when one of these animals was put into her cage, "she flew at it and slew it with a single bite, leaving it instantly, as a well-trained terrier does the rat it has killed." The first occasion of Anna Maria having little ones was quite an event. "When I went to the box, as usual, to give my little rodents a scrap of whatever I might have had, I found Augustus (the male) sitting out in the cold and looking terribly sheepish. On opening the sleeping compartment, there was Anna Maria, with something like a smile upon her shrewish little countenance, keeping watch and ward over nine ridiculously naked little offspring. On these occasions Augustus was completely effaced. He shirked the slightest responsibility; and I always had to make him up a separate bed, for sleep with his children he would not. If by chance he was forced to walk among them, he did so with an anxiety that would have done credit to an elephant stepping between eggs. As they grew up, assumed hair, and began to run about, he would allow them to take liberties with him, and even rob him of tidbits." The master

thought the hay the naked little fellows were lying upon too rough for their tender skins, and put wadding in its place. "But, with a sneer of contempt for the stupidity of men in such matters, Anna Maria promptly cast out the wadding and bumped her progeny upon the hay again." In washing them, "she would roll them over and over with her paws, and lick them till the sparks flew, and they would utter plaintive little squeaks." But they throve splendidly. "Every night this graceful couple gamboled about my table while I read or wrote. It was a delight to me to watch them at their toilet or eating the food which they held in their delicate little paws. . . . When tired of play, they would clamber up to my shoulder and slumber, huddled together like two love-birds." Anna Maria at last died of a cold, and her place was supplied by a new female, whose chief peculiarity was that as soon as she had a family she would bite off her babies' heads."

Cannibalism among Rats.—Mr. W. Mattieu Williams believes that rats are, upon occasion, voracious cannibals, devouring one another by wholesale and without mercy. Being troubled beyond endurance by these pests, and getting no relief from dogs, ferrets, and cats, and fearing poison, he tried the effects of stuffing the holes with broken glass. "This was successful, and some curious results accompanied the clearance. At first, there were streaks of blood on the kitchen-floor in considerable quantity, and distributed all over it. These appeared on several mornings. At about the same time, and subsequently, much scampering and screaming was heard beneath. This was followed by a rapid reduction of the number of the enemy. My theory," says Mr. Williams, "is, that when any one rat was wounded by the glass, the scent of blood excited the voracity of the others, and a cannibal struggle occurred; that this continued till extirpation followed—the more fighting, the more bloodshed and the more cannibalism." Mr. F. W. Halfpenny partly confirms this view in "Science Gossip," where he says that the black rat is still to be met with at most of the London docks; that the Norway or sewer rat not only kills its victim, but devours it. He describes skins of freshly killed black rats turned inside out, and found in various drawers, boxes, etc., and states that this treatment of their victims is usual with rats. As an experiment, Mr. Halfpenny gave the carcass of a white rat to one of the black and white variety. It was eaten, only a few bones of the head remaining attached to the everted skin.

Coal-Dust in Fire-Damp Explosions.—The Royal Prussian Fire-damp Commission has carried out a series of experiments in the Royal Coal-Mine near Neunkirchen, the results of which go far to confirm Mr. W. Galloway's theory of the agency of coal-dust alone, and in conjunction with fire-damp, in propagating explosions in mines. At the mine in question is a blower of fire-damp at a depth of 131 yards below the surface, which gives off 0·9 cubic foot of gas a minute. For the experiments cannon were planted at the closed end of a horizontal gallery 167 feet long, having a branch 33 feet long, starting at a distance of 93 feet from its closed end. The branch gallery was closed at both ends with two-inch planking. One gun was fired when the gallery was free from fire-damp and from coal-dust; the flame of the shot was a little over 13 feet long. In a second experiment the floor of the gallery was strewed with coal-dust 1·17 inch thick for a length of 65 feet. The shot gave rise to a loud detonation, and the resulting flame filled the gallery to a distance of 88½ feet. The inner planking of the branch gallery was broken. In the third experiment the gallery-floor was strewed with coal-dust for a length of 130 feet. The flame traversed the whole length of the gallery with great velocity, and came out at the open end to a distance of 16 feet, or 183 feet in all. It also emerged from the branch gallery to a distance of several yards. The outer partition of this gallery was broken into small fragments. For the fourth experiment, the partitions in the branch gallery were replaced, coal-dust was strewed on the floor for a distance of 65 feet, and a volume of 35¼ cubic feet of fire-damp was introduced and completely diffused. The firing of the shot produced a flame 190 feet long, accompanied by a report like a thunder-clap. The inner brettice of the

branch gallery was broken and drawn several yards into the main gallery, but the outer one remained intact. The incidental effects of the last two shots also indicated how tremendous a force had been let loose when coal-dust formed one of the elements of the explosion. These experiments were typical of two hundred similar ones that had been made with from one to seven guns, all marked by results sustaining the coal-dust theory.

Medical Virtues of Dog's Tongues.—M. Reimach having called attention to the mention, in the recently discovered inscriptions at the Temple of Esculapius, in Epidaurus, of children having been cured of blindness at that sanctuary by having their eyes licked by the sacred dogs, M. Henri Gaïdoz states that he has discovered the faith and practices of the dog-cure among several peoples and in a number of religions. The Hindoos believe that the English kill dogs to obtain possession of a sovereign remedy which is found in their tongues. In a Venetian legend, St. Roch was cured by a balsam distilled from the tongue of his dog. Dogs' tongues are considered to have medical virtue by many people in Portugal, France, and Scotland. In Bohemia they let dogs lick the faces of new-born children for "good luck." A belief in the existence of divinities issuing from dogs, whose office it was to lick the bruises of the wounded, once prevailed in Armenia. In a scene in one of Aristophanes's plays, Plutus recovers his sight in the Temple of Esculapius after being licked by two serpents which the god sent for that purpose in answer to his prayer.

Observations in the Sahara.—Dr. Oscar Lenz, whose account of his journey through Morocco, the Sahara, and the Soudan, to Timbuctoo, has been recently published, is the fourth European traveler who has reached the famous "Queen of the Wilderness," as the desert metropolis is called, during the present century. Having entered the city from the north, and then going from it westward and down the Senegal to the Atlantic coast at St. Louis, he has demonstrated the accessibility of Timbuctoo from both directions. One of the results of the surveys he made on his journey will probably be the death of the theory that the region of the Sahara has ever been a marine basin, at least since the early Tertiary epoch. The whole of the western section of the desert traversed by him was proved not to be a depression, as has been assumed, but an irregular plateau; standing in the north at a mean elevation of from eight hundred to one thousand feet, and even at Tandeni, its lowest level, still maintaining an altitude of four or five hundred feet above the Atlantic. The surface formations have nothing in common with marine sedimentary deposits, but are all evidently the results of weathering. The numerous dried-up water-courses, whose deep channels are distinctly the effect of erosion, also show that this part of the desert has been dry land for many ages. These wadies radiate from the central highland north and northeast to the Mediterranean, east to the Nile, south to Lake Chad and the Niger, and west to the Atlantic, and have been in their day full of water. Hence, it appears that, down to comparatively recent times, the Sahara was a well watered and wooded region, thickly inhabited by agricultural and pastoral communities. What has caused this change in climate? Dr. Lenz attributes it, not as Peschel has supposed, to the dry northeast polar winds (for these in the Sahara yield to the northern and northwestern atmospheric currents), but largely to the reckless destruction of the woodlands which once covered extensive tracts in the region.

Value of Fruit as Food.—The "Lancet" regards the increased use of fruit in ordinary diet as one of the most salutary tendencies of domestic management in our day. The starchy and saccharine components of fruit, while they are not equal in accumulated force to the more solid ingredients of meat and fat, are similarly useful in their own degree, and have the advantage of greater digestibility. Other advantages are the locally stimulant action of many sub-acid fruits, its control of a too active peptic secretion, and its influence of attraction upon the alkaline and aperient intestinal juice, to which further effects that aid the maintenance of a pure and vigorous circulation are indirectly due. "Thus it follows,

on the simplest principles of physiology, that other essential organs, such as the skin and kidneys, are relieved by the transference of part of their excretory function to the bowel and act with greater ease, the general vascular system is lightened by this regulating drain, and its faculty of absorbing the waste products of food and work is encouraged in proportion." Only persons of gouty and rheumatic habit, or of tendencies to diarrhœa, dysentery, or saccharine diabetes, will be likely to find fruit in any moderate quantities to disagree with them, while dyspeptic persons will find it almost wholly beneficial.

Formation of Peat.—For the growth and formation of peat—which is vegetable matter in a semi-decomposed state—is required a climate sufficiently moist to foster the growth of the plants of the remains of which it is composed, and at the same time cool enough to retard, under certain conditions, the decomposition, beyond a certain point, of successive generations of those plants. Accordingly, we find it most abundantly distributed in latitudes above 45° in either hemisphere. In Ireland, the peat-bogs cover about one seventh of the surface. Peat-bogs are classified as those which have ceased to grow and those which are still growing. Some of the former class must be of enormous age. In many bogs in Ireland the deposit is from fifteen to thirty feet deep, and in Scotland this depth is frequently exceeded. Each year's growth, according to Mr. Kinahan, is represented by a layer of lamina, and these lamina are, on an average, in white turf one hundred, in brown turf two to three hundred, in black turf from six to eight hundred to the foot. It is easy with these data to compute approximately the probable age of the bogs; but the result of the calculation is liable to variations according to the manner in which the bog was formed; for the rate of growth is subject to many fluctuations, not only in different bogs, but in different parts of the same bog. When two layers of wood are found in peat, the lower forest usually proves to have consisted of oak, and the upper one of pine. Remains of the great Irish deer are very common in the bogs of Ireland, and human relics are often found. No chronological estimates can, however, be based upon the presence of such relics, for articles having weight will easily sink through the soft mass. In districts where peat is plentiful it is extensively used for fuel, for which purpose the turf is cut from the bogs in narrow rectangular masses a foot or eighteen inches long, and prepared by drying. It is not well adapted for use in manufactures, for its heating power is low. Peat-charcoal has, however, been used with advantage in smelting iron, and it possesses very powerful antiseptic and deodorizing properties. Considerable quantities of peat-land have been reclaimed and brought under cultivation. In its natural state the soil is sour and unfit to promote plant-growth, but when drained and treated with lime it may be brought to a high degree of fertility. When the peat-bog is situated near to limestone, the process of reclaiming the land is cheap and the result is profitable.

A Scientific Commonplace-Book.—The purpose of "The Scientific Roll," a new serial kind of encyclopædia, or commonplace-book, projected and begun by Mr. Alexander Ramsay, is to cull, classify, and embody in a shape conveniently accessible, all the important statements of fact and theory that now lie scattered and substantially out of reach to any one man in the six thousand scientific periodicals of the day. The systematization of notes on this plan results in a most compendious classification of all that is wanted in scientific literature, in such a way that lines of thought are suggested to the reader, and facilities are offered for following them out which books, as a whole, do not afford. No correction is given, or comment upon the views of the several authors, but each one speaks for himself, and the reader is left to choose to what he will hold. The first volume, just published by Swan, Sonnenschein & Co., London, includes the literature of climate, in which a prominent place is given to a very interesting bibliography. One of the oldest works catalogued is said to have been written in the thirteenth century, and was printed by Caxton, under the title of "Image or Mirror of the World." But, as an English journal admits in its review of the publication, "it is not till

we reach the year 1789 that we find the germ of the science, in a paper by Benjamin Franklin, under the somewhat timid title, for so bold a meteorologist, of "Meteorological Imaginations and Conjectures." This is followed by contributions from Lamarck, Saussure, Playfair, and Humboldt. The number of references to the year 1800, when Humboldt's name is first mentioned, is only three, while in 1880 the number has increased to eighty-four. America, as the country affording most facilities for systematic observations, has the leading place in the list all the way through.

Enlargement of the Sun and Moon in the Horizon.—Various hypotheses have been proposed to explain the apparent enlargement of the sun and moon in the horizon over the size they seem to present at the zenith. Experiments recently made by M. Stroobant, in Belgium, indicate that the cause of the phenomenon is a physiological one. In a darkened room, M. Stroobant had fixed to the ceiling two electric stars about eight inches apart, and on the level of his eye two similar stars, the distance between which could be varied at pleasure, while the observer's eyes were at an equal distance from either pair. When the pair of stars on the level of his eye were so adjusted as to appear at the same distance as the pair in the ceiling, they were proved on measurement to be only six and a half inches apart. He then transferred his observations to the actual stars, selecting pairs at sensibly equal distances apart in the horizon and in the zenith, and afterward measuring their real angular separation as marked on the celestial globe. The apparent separation of the stars in the horizon was increased in almost precisely the same degree, the ratio of the real distances, which seemed to the eye to be the same, being as 100 in the zenith to from 79·5 to 81·5 in the horizon.

The Vegetation of Gutter-Stones.—Dr. Hugo Winnacker, who devoted eleven full months to the study of the subject, has published a paper on the "Vegetation of Gutter-Stones and its Relation to Infectious Diseases." The subject is one of no little importance, for, if the gutters of our streets really harbor infectious plants or germs, they are capable of being very dangerous agents for the spread of disease. Parts of them are exposed to being dried every day, and when they are in that condition the germs might be taken up by the wind and scattered everywhere, to become active whenever they are supplied with moisture. Dr. Winnacker has found that the vegetation of the gutter-stones consists of green algæ and fungoids. The algæ are harmless and even beneficial, for they grow over the fungoids and at their expense, and help to keep them down. They should therefore be encouraged by not removing them, and by flushing the gutters, so as to supply them with the elements favorable to their nutrition. Most of the fungoids likewise appear to be harmless, but some of them may be dangerous, and, as it is hard to distinguish their qualities, it is well to be on the watch against them. Two of the fungoid forms, quite abundant at Göttingen, are especially described. One, a micrococcus and ferment, grows in a reddish-brown coating from early in the spring till late in the fall. Another, a mold, grows in thick masses all the year round. The character of the vegetation may be different in different cities.

Difficulties of Underground Telephony.—The difficulties in the way of at once laying the telegraph and telephone wires underground in London are succinctly stated in the "Saturday Review." The inductive effects in the telephone wires are already annoying enough, when there is room to spread the wires in the air. They would be greatly multiplied if the conductors were bunched together, as they would have to be, to be put in a tube underground. The retardative effects would also be largely increased, to a serious extent, in fact, in the case of the telephones, for they depend upon abrupt and rapid changes in the strength of the current, and these would be so far nullified as seriously to impair the clearness of the articulation if the line were of any considerable length. The expense of construction would be largely increased by the necessity of coating the wires; while the coating, mainly composed of gutta-percha, is perishable, and constantly giving rise to "faults." A system of sub-ways, like the

sewers of Paris, or the underground avenues, that might be made by connecting the sidewalk vaults of New York, seems to be an indispensable prerequisite to any practicable general location of electric telegraphic and other wires under the ground. Nevertheless, the overhead electric-light wires are a nuisance, and fitly entitled to the epithet, "a Damocletian terror," which the London "Lancet" applies to them.

Food-Value of "Whole-Wheat" Flour.—Dr. Campbell Morfitt, who has been largely instrumental in introducing improved forms of bread and new methods of bread-making, has reported an experiment he has made to ascertain the relative value of common flour and of his "whole-wheat" flour. The objections to the old Graham flour, that its coarse bran was irritating to the digestive organs, were well founded. The "whole-wheat" flour is free from this fault, for the bran is not coarse or sharp-edged. Dr. Morfitt makes three kinds of flour: the crude, representing the entire grain; a standard refined granular meal, representing ninety-three or ninety-four per cent of the cleaned grain; and a pearl-white meal representing all the farina of the grain with some cerealine, about eighty-three per cent of the whole. Given weights of each of these were carefully brushed over a fine wire-cloth till all the farinaceous portions had gone through. That which was left on the sieve—called proximate bran—amounted, in the mean, to 18·28 per cent of the crude, and 12·19 per cent of the standard meal. Therefore, wheat may be said, generally, to consist of 81·72 per cent farina and 18·28 of branny matter. The proximate brans were next inclosed in fine cloths and kneaded under relays of cool water till the latter ceased to become cloudy, and by this treatment were reduced in weight rather more than one half. The residue left from this treatment was called absolute bran. It exists in a fixed ratio to the meal in all the wheats indifferently of 9·65 per cent from the crude, and 5·80 per cent from the standard meal. Thus, the total of actual bran in any wheat does not exceed ten per cent. The proximate bran was then subjected to an artificial digestive process, to discover how much more of its substance it would yield in that way. The quantity of "ultimate" bran left after this experiment was reduced by 18·44 per cent, or to 7·87 per cent for the crude meals, and by 21·38 per cent, or to 4·56 per cent for the standard meals. The more powerful natural digestion of the stomach must certainly extract still more from the meals. "Results could not be more impressive than these," says Dr. Morfitt, "as to the superior nourishing value of whole-wheat meal, for they prove that the separation and rejection of the bran must inevitably impoverish the residual farina of the flour."

Poisonous and Medicinal Herbs in India.—No country is better supplied with medicinal as well as poisonous herbs than India. The waysides and ditches abound in plants that possess some strange, and some the most deadly qualities. One of the most common of these plants is the *datoora*, with its large white flower, and leaves resembling those of the hollyhock. It is well known as a remedy for asthma, and its leaves are used in the shape of cigars or "tobacco," but its seeds are a subtile and powerful poison, in small quantities causing temporary insanity, and in large either permanent injury to the brain or death. The natives believe that it is used by robbers to aid them in their operations. The *madăr* grows from two to four feet high in isolated groups along road-sides and in open, sunny places. It is soft and branching, with broad, thick, dark-green leaves covered with down, and large white waxen flowers tinged with pink toward the center. The application of the leaf is a sovereign remedy for sprains, swellings, and pains. The strangest and most powerful property of the *madăr* resides in the milk, which exudes abundantly on the slightest scratch of its succulent leaf or stem. The natives profess to use it for any obstinate sore, especially in the nostril, but when swallowed it produces spasms of hilarious intoxication of which the patient recollects nothing after they are over. The natives say that if a probe is formed from a mixture of the *madăr*-milk with a pounded *ruttee*-seed, dried and hardened in the sun, and if the skin is pricked with this and the point left, death will follow imperceptibly and painlessly in two or three days, leaving no trace of the cause but the faintest speck

like a mosquito-bite where the skin was probed. The wild *ganja*—to which the hasheesh-plant corresponds as a cultivated species—has similar intoxicating effects, except that it is less injurious to the system. The natives chiefly use it spiced for the hookah, or as an infusion for drinking. From long continuance or excess it is a frequent cause of insanity; and this may pass away on discontinuing the use, or result in more or less permanent imbecility. It is used sometimes as a medicine for cattle. The number of herbs considered medicinal by the natives is endless. Hardly a weed grows but they find some virtue in it for some ailment or another. The large leaf of the castor-oil plant, heated and applied externally, is used for allaying local inflammation and pain. The leaf and bark of the *neem*-tree are similarly applied. A small weed like clover, gathered among the grass, is applied to the temples to allay headaches, or otherwise as a counter-irritant, as we use mustard. The *cherita* is a well-known tonic and fever preventive; and the milk of the *chutwan*-tree is used for stuffing what few Hindoo teeth come to be in need of that process.

NOTES.

Professor John S. Newberry has described, in the "Annals" of the New York Academy of Sciences, some peculiar screw-like fossils from the Chemung rocks of Northern Pennsylvania and Southern New York, which at first sight suggest a resemblance that is not real to the fossil fruit Spirangium. Two species are identified, of one of which only one specimen has been found. They consist of a cylindrical or fusiform body traversed by double spiral revolving ridges, which make them look very much like common screws. The generic name of *Spiraxis* has been given to them, with the specific names of *major* and *Randalli*. Professor Newberry regards them as casts of sea-weed stems.

In a paper on "The First Notice of the Pine-Grove or Forest River Shell-heap," Mr. F. W. Putnam reprints the report made by John Lewis Russell in 1840 to the Essex County Natural History Society. Up to this time it had hardly been doubted that these heaps were of natural origin, and Mr. Russell does not appear to have suggested any other view.

Helen C. De S. Abbott has published an analysis of the bark of *Fouquieria splendens*, or the ocotilla-tree, a thorny plant, of the order *Tamariscineæ*, native to the region of the Mexican boundary-line, which grows in the shape of a low fan, from eight to twelve feet high, bearing foot-long scarlet, trumpet-shaped flowers, and which the people find useful for making fences. The bark supplies a wax which differs generally in its properties from known vegetable waxes, and is evidently a new wax peculiar to this plant. The name ocotilla-wax is proposed for it.

Dr. Giles, of the Indian Government's surveying steamer Investigator, has obtained some animals from the Bay of Bengal which appear to be new, and has proved that "the Swatch," at the mouth of the Hoogly, is a deep, submerged valley, forming part of the original depression of the bay.

An interesting new feature of this year's May-day celebrations in London was a procession of cart-horses, similar to those which have been regularly held in some of the towns of the United Kingdom. About a hundred teams participated. No prizes were offered, but each driver received an illuminated card commemorative of the occasion, and acknowledging the evidences afforded of "care, attention, and kindness to animals." A regular observance of this kind might be made the means of greatly encouraging proper treatment of beasts of burden.

M. Witz states, as the result of observations he has been making for some time on atmospheric ozone, that the proportion of ozone in the air of Paris last year was inverse to the mortality from cholera.

According to a Moscow paper, only 21 per cent of the children attending school in Russia are girls. The proportion varies with the religion, being greatest among Protestants, 45·4 per cent; next among Jews, 34·1 per cent; next among Roman Catholics, 14·4 per cent; and lowest among Greek Catholics, 12·3 per cent.

M. Stanislas Meunier has described some silicious pebbles which are quite numerous in the quaternary gravels of the valley of the Loing, France, that are remarkable for being hollow and inclosing, together frequently with a loose stony nucleus, liquid water. They are about forty-five millimetres in diameter, and the water may be heard to strike against the walls of the cavity when the stones are shaken. The only way M. Meunier can account for the water getting into the pebbles is by its seeping through the pores, for not a sign of a crack can be seen with the eye or by the aid of a strong glass.

SEVERAL cyclopædias contain the statement, in substance, that no land in Connecticut rises above a thousand feet in height. Professor Asaph Hall writes to "Science" that, according to Mr. G. M. Bradford's surveys, several points in the northwest part of the State are higher than this, and mentions six mountains that exceed 1,600 feet. They are: Ivy Mount, Goshen, 1,642; Haystack Mount, Norfolk, 1,672; Bald Mount, Norfolk, 1,770; Bradford Mount, Canaan, 1,910; Bear Mount, Salisbury, 2,100; and Bruce Mount, Salisbury, 2,300 feet.

UNDER the promptings of the universal recognition of the truth that, for Japan to take the rank she should hold among civilized nations, her literary and educational work must be freed from the trammels of the Chinese ideographs, a society—the Rōmaji Kai—has been formed to promote the general adoption of the Roman letters. Its committee, composed of native and foreign scholars, has drawn up a scheme of transliteration, and a monthly journal—the "Rōmaji Zasshi," which, besides this subject, will discuss general topics and publish classical and original literary papers—has been begun, to introduce the new system to the people.

DR. CORNISH, a student of cholera, proposes that a certain proportion of the persons who are condemned to death every year in India be used, their own consent having been obtained, as subjects for experiments on the transmission of cholera; further punishment to be remitted if they survive the tests.

A DIVISION of economic ornithology has been established in the Entomological Bureau of the Office of Commissioner of Agriculture, and Dr. C. Hart Merriam, Secretary of the American Ornithologists' Union, has been appointed to take charge of it. Its special field of investigation will be the inter-relation of birds and agriculture, and will include the relations of birds and insects, the food and habits of birds, and the collection of data bearing on the migration and geographical distribution of North American birds.

M. J. J. MARTINEZ proposes a universal subscription for the purpose of boring a hole, thirty by one hundred and fifty feet in diameter, down into the earth, at which convenient stations may be fixed for the observation of all kinds of subterranean phenomena.

LIEUTENANT VAN GÈLE, of the French Equatorial Station, gives the following list, with the weights, of the various articles of costume of a Congo negro lady: A copper ring on each ankle, ½ kilogramme; brass-wire leglets on each calf, 1 kilogramme each; a petticoat of banana-fiber cloth, twenty inches long and nine inches wide, $\frac{1}{10}$ kilogramme; a bell fastened with a belt, ½ kilogramme; a copper collar around the neck—the most important garment of the dress—27 kilogrammes. The total weight is 29·210 kilogrammes, or nearly 75 pounds—about the load of a European infantry-soldier—of which less than half an ounce is devoted to the purpose of real dress.

THE French Association for the Advancement of the Sciences was to meet at Grenoble on the 12th of August, under the presidency of Professor Verneuil. The meetings would continue till the 20th, after which a series of excursions was projected, to last till the 24th. Two conferences were appointed: "On the Alimentary Resources of France," by Dr. Jules Rochard; and "On the New Paleontological Gallery of the Museum," by M. G. Cotteau.

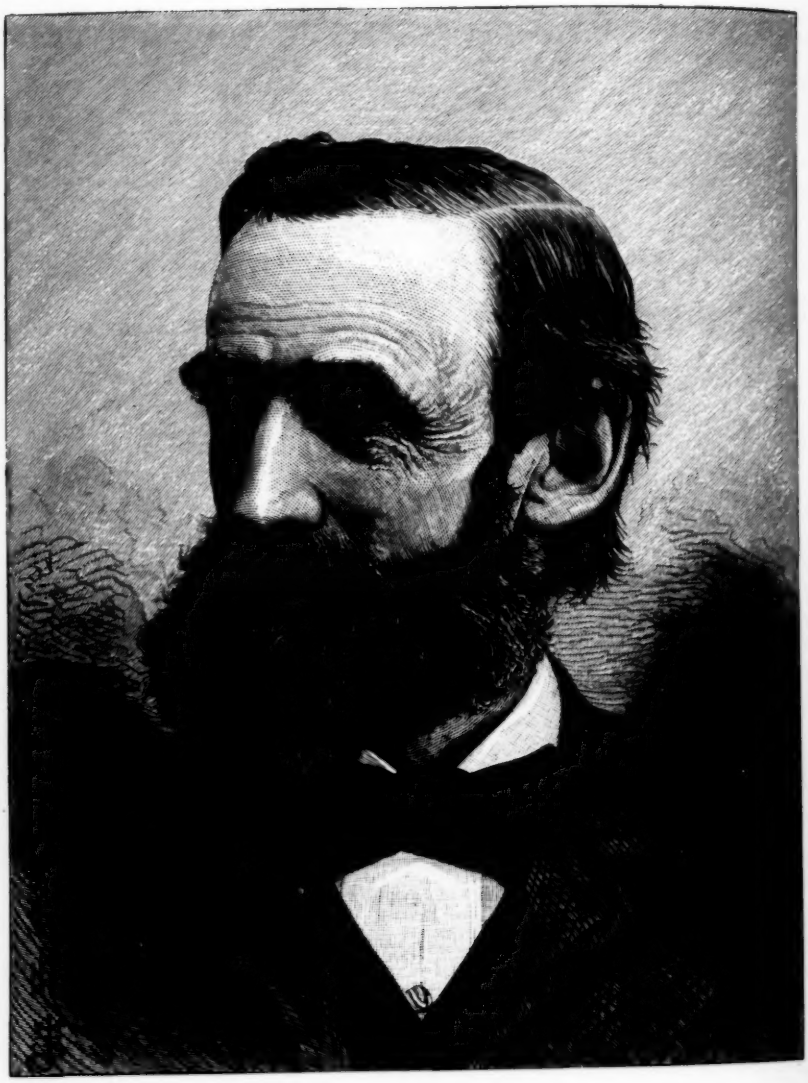
EXPERIMENTS reported by M. Guignet to the French Academy of Sciences confirm the views of M. Frémy that the behavior of chlorophyl, or the coloring-matter of leaves, is usually like that of an acid. M. Guignet has obtained chlorophyllate of soda, and from it, by double decomposition, salts of lime, baryta, and lead.

MM. MUNTZ and MARCANO have observed that nitrification of the soil is going on in the equatorial regions of South America on an extraordinary scale. At some points the constituents of the mold are cemented together in a kind of paste by enormous proportions—sometimes forty per cent—of nitrate of lime. The origin of these conditions is traced to the numerous mountain-caves, which are inhabited by legions of birds and bats, whence the streams carry the guano over extensive areas.

OBITUARY NOTES.

DR. HENRI MILNE-EDWARDS, the eminent French naturalist, and the successor of Geoffroy St.-Hilaire in the chair of Zoölogy at the Museum of the Academy of Sciences, died in Paris, July 29th, in the eighty-fifth year of his age. A portrait and sketch of his life and works were published in "The Popular Science Monthly" for February, 1883.

ROBERT VON SCHLAGINTWEIT, Professor of Geography and Ethnology at the University of Giessen, has recently died, at the age of fifty-two. He was the youngest of three brothers who were commissioned by the British East India Company, on the recommendation of Humboldt, to explore India and the mountain-regions of the northwest.



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